ATTACHMENT 16-1

UNIQUE SPECIAL PROVISIONS:

Intelligent Transportation Systems (ITS)

TRAFFIC DETECTORS

Microloops

Except as otherwise provided herein, magnetic microloop vehicle detectors shall be installed under pavement. Design-Build Contractor shall provide handholes and cross-roadway conduit at detector locations to provide convenient access to the microloops for maintenance.

Two detectors shall be provided at each location for a speed trap configuration. Magnetic microloops shall be installed under pavement. Design-Build Contractor shall provide handholes and cross-roadway conduit at detector locations to provide convenient access to the microloops for maintenance.

Materials

Design-Build Contractor shall be responsible for furnishing, insuring, and transporting all materials associated with the microloop detector assembly and the controller cabinets.

All materials shall be furnished in accordance with the material requirements as stipulated under Project Standards, including probe sensors, lead-in cables, conduits, pullboxes, home-run cables and splice enclosure kits, traffic monitoring controllers, controller cabinets, and all communication interfaces between the controllers to the lane probes and to the center.

Materials shall be as follows or Department approved equivalent:

1. Canoga 922 2-Channel Vehicle Detector Card
2. Canoga Vehicle Detector Card Power Supply
3. 3M Scotchcast 3831 Buried Service Wire Splice Installation Kit
4. Canoga 3003 Home Run Cable

Design Criteria

The microloop detectors shall be designed and installed in and protected by conduits. Design-Build Contractor shall coordinate the design and installation of microloop detectors with the pavement design and construction.

Construction Requirements

The microloop detectors shall be inserted into 3-inch PVC conduit placed below the pavement surface as specified by the manufacturer. For multiple lanes, multiple microloop probes shall be placed and interconnected in a series to obtain required lane coverage and to remove magnetic-induced noises. All lead-in cables shall be spliced into the home-run cables in splice enclosures in pullboxes along the roadside, which shall be sealed and insulated from water damage in accordance with manufacturer’s specifications.

The traffic monitoring controller shall be configured to communicate with field probes to detect vehicle volumes along with user-defined classifications, speeds, and occupancies by lane in user-defined intervals (typically 2 minutes to 15 minutes) with accuracy levels in accordance with

manufacturer's specifications. For any time interval the maximum error rate shall not exceed ±5 percent compared with ground truth vehicle data obtained visually over a 15-minute period for every detector installation. The error rate shall be determined using visual counts and speeds measured with a radar gun. The test shall be performed by the Contractor in the presence of the Engineer. If detector sensitivity or calibration settings are adjusted in order to meet this test, the new settings shall be recorded on the wiring diagram in the cabinet.

For vehicle counts, use the following standard Department form:

RTMS ID #			NOTES					
LOCATION								
FINE TUNE								
SENSITIVITY								
SAVED FILE NAME			When verifying counts a minimum of 50 vehicles must be counted					
BARRIER/TYPE	YES/NO		BETWEEN LANES					
ZONE	1	2	3	4	5	6	7	8
DIRECTION								
LANE (FAST MID SLOW)								
MANUAL COUNT								
RTMS Lap Top COUNT								
% ERROR								
MESSAGE PERIOD____ [SECS]			POLL MODE ___		TECH INIT		APPROVED	

All interface cables and communication ports shall be connected and configured to complete the communications and control from center to field cabinet and from field cabinet to lane probes.

At a minimum, the detector shall provide the following vehicle classes on Table 4-A-1, FHWA Traffic Monitoring Guide:

Vehicle Class	Recommended Length
Passenger vehicles (PV):	<13 feet
Single unit trucks (SU):	13 - 35 feet
Combination trucks (CU):	35 - 61 feet
Multi-trailer trucks (MU):	61 - 120 feet

The microloop detectors shall also be configured to detect and report stopped or dysfunctional vehicles in the direction of travel. Application-specific software shall also be provided to enable traffic data reporting and Incident detection in the TMC.

Design-Build Contractor shall provide power and communications connections to the control cabinet to which the microloop detectors report to transmit traffic data to the TMC for traffic management and Incident detection.

Microwave Radar Detectors

Microwave radar detectors shall be used where conditions are not appropriate for the installation of microloop detectors. These locations shall be approved by INDOT.

Materials

Design-Build Contractor shall be responsible for furnishing, insuring, and transporting all materials associated with the microwave radar detector assembly and the controller cabinets. The Microwave Detector shall include the following items:

1. Microwave Detector Unit with mounting plate installed
2. Mounting ball-joint bracket and l-inch lynch-pin
3. Matching MS plug and back-shell, D-Type 9-pin RS-232 connector and back-shell
4. Ready-made 8-zone cable (cable length as required)
5. Calibration and operating software and software licenses for all locations

All mounting hardware, conduit, conduit bushings, conduit straps, cables, serial converter, power converter, surge suppressor, wires, connectors, support attachment arms, grounding wires, ground rods, grounding cables, weather heads, etc. necessary to complete the Microwave Detector as specified herein shall be supplied and installed as recommended by the manufacturer.

Design Criteria

The microwave radar detectors shall be designed, furnished, and installed side-fired on equipment poles or structures (e.g., overhead sign supports). The detectors and equipment cabinets shall be roadside-mounted and continuous along roadways, with a maximum spacing of 0.3 miles. Pending Engineer approval, spacing may be adjusted slightly when in the vicinity of a CCTV camera installation site, such that detectors are co-located with the nearby CCTV camera sites.

The microwave ranging radar detectors shall be installed on all newly constructed roadways and interchanges to provide traffic monitoring and travel-time detection. For highway installations, the detectors shall provide the following traffic data measurements with the accuracy stipulated by Department TMC:

1. Vehicle volumes by lane
2. Travel speeds by lane
3. Vehicular occupancy by lane

A field controller shall be provided to process the field data collected from the detector and transmit to INDOT TMC. Design-Build Contractor shall be responsible to install and align each detector with adequate setback distance in accordance with the manufacturer's requirements to provide radar coverage over the entire detection zones. In any case that a detector's location is within the clear zone, safety guide railings or traffic barriers shall be provided for protecting ITS devices and their supports as required by state and Occupational Safety and Health Administration (OSHA) standards.

Construction Requirements

Design-Build Contractor shall be responsible for the design and installation of the microwave radar detectors. The microwave radar detectors shall be aligned and aimed to the target roadway, with clear coverage of traffic without the interference of any other microwave devices or vertical surfaces such as bridges. The setback distance and mounting height shall be site-surveyed and approved in accordance with the manufacturer's requirements to allow maximum detection coverage over all lanes.

Design-Build Contractor shall provide power and communications connections to the control cabinet connecting to microwave radar detectors. The composite power and data cable shall meet the manufacturer's specifications on communications protocol requirements and shall be continuous without splices between the cabinet and the detector assembly. Cable ends shall be kept sealed at all times during installation using an approved end cap until connectors are installed. Tapes shall not be used to cap the cable end at any time.

Wireless Sensor Detection System

Wireless sensor detection shall be used where conditions are not appropriate for the installation of microloop detectors. These locations shall be approved by INDOT.

Materials

Design-Build Contractor shall be responsible for furnishing, insuring, and transporting all materials associated with the wireless sensor detection system.

Wireless sensors shall be rugged and designed to fully operate in the outdoor, in-pavement environment. The sensor housing shall meet NEMA Type 6P enclosure rating and IP68 ingress protection.

Sensors shall have multi-axis magnetic field sensing and shall self-calibrate automatically. The sensors shall have a battery life of at least 10 years. Sealant shall be a fast-drying epoxy suitable to withstand the long-term, harsh conditions of the roadway.

Access point shall provide bi-directional wireless communications with the sensors. It shall enable the unique addressing and configuring of each sensor and the wireless upgrading of firmware. Operating software and software licenses for all locations shall be provided to the Department.

Repeaters and radios shall be provided if required to ensure reliable communications between the in-pavement sensors and the access point controller. The repeaters and radios shall be from the same manufacturer as the wireless sensors and designed specifically for this function.

All mounting hardware, straps, cables, power supplies, surge suppressor, wires, connectors, support attachments, grounding wires, ground rods, grounding cables, weather heads, etc. necessary to complete the wireless sensor detection system as specified herein shall be supplied and installed as recommended by the manufacturer.

Design Criteria

The wireless sensor detection system access points and repeaters shall be designed, furnished, and installed on equipment poles or structures (e.g., overhead sign supports). The installation and spacing of in-pavement wireless sensors, repeaters, access points and radios shall be in accordance with the manufacturer's instructions.

The wireless sensor detection system shall be installed on newly constructed roadways and interchanges to provide traffic data monitoring. For highway installations, the detectors shall provide the following traffic data measurements with the accuracy stipulated by Department TMC:

1. Vehicle volumes by lane
2. Travel speeds by lane
3. Vehicular occupancy by lane

A field controller shall be provided to process the field data collected from the detector and transmit to INDOT TMC. Design-Build Contractor shall be responsible to install each sensor at the proper depth and sealing in accordance with the manufacturer's requirements to provide optimal readings and performance. In any case that a support structure for wireless sensor detection equipment is within the clear zone, safety guide railings or traffic barriers shall be provided for protecting ITS devices and their supports as required by state and Occupational Safety and Health Administration (OSHA) standards.

Construction Requirements

Design-Build Contractor shall be responsible for the design and installation of the wireless sensor detection system. The in-pavement wireless sensors shall be centered in each lane and installed at the proper depth and sealing for optimal performance in accordance with manufacturer's instructions. Each lane shall have a pair of sensors installed for speed measurements. The distance between pairs of sensors shall be a preset distance and configured in the software according to the manufacturer's instructions. At each site, a wireless sensor shall be installed in each lane and configured in the system.

ROADWAY WEATHER INFORMATION SYSTEM

Materials

Design-Build Contractor shall be responsible for furnishing, insuring, transporting, and storing (for the interim) all materials associated with RWIS and control cabinets. Materials include sensors for pavement surface conditions, subsurface temperature probes, atmospheric sensors, wind speed and direction detectors, precipitation and visibility sensors, and video imaging for precipitation and moisture.

Design Criteria

The Road Weather Information System (RWIS) shall provide both air and pavement surface weather data, including the following:

Atmospheric data: temperature, precipitation, visibility, humidity, solar radiation, remote camera imaging, and wind data.

Surface/subsurface data: pavement temperature, subsurface temperature, surface condition, amount of de-icing chemical on roadway, and freezing point.

Design-Build Contractor shall be fully responsible for the design, fabrication, and installation of the RWIS and control cabinets. Design-Build Contractor shall be responsible for the design and installation of maintenance platforms, and safety guide railings or traffic barriers if within clear zones, as required by OSHA.

Construction Requirements

Design-Build Contractor shall be responsible for the installation of the RWIS and control cabinets.

Design-Build Contractor shall provide power and communications connections to the RWIS and control cabinets in accordance with requirements of the RWIS manufacturer to provide a complete RWIS system. The Design-Build Contractor shall coordinate with the utility to establish electrical service for RWIS equipment.

Manufacturer software shall be configured for data monitoring and detecting alarms/warnings from pavement and subsurface probes of the proposed RWIS using approved thresholds.

CCTV ASSEMBLY

Description

The Contractor shall provide a CCTV Assembly at each site shown on the Plans. The CCTV Assembly includes the camera, lowering system and hybrid composite cable for each assembly.

Materials

The CCTV Assembly shall consist of the following components:

1. One camera with Pan Tilt Zoom
2. One camera lowering system as described elsewhere in the provisions.
3. CCTV Hybrid Composite Cable as described elsewhere in the provisions.

The CCTV camera shall be a WTI Model: Sidewinder H.264 Standard Definition Model Number SW720-24-H.264-SD.

The contact information for the cameras and associated equipment is as follows:

Mr. Perry Wolfe

P.T. Wolfe Associates Inc.

2017 Garey Rd. NE

Junction City, OH 43748

Telephone: 740-987-2550

Fax: 740-987-2477

Mobile Phone: 740-503-2148

Construction Requirements

CCTV Assemblies shall be installed in accordance with the manufacturer’s instructions and per the plans. All materials shall be installed in a neat and professional manner. All installation services will comply with all warranty provisions and warranty contract maintenance services in accordance with these specifications. All installation services shall comply with all local and state electrical codes, and Motorola R-56 requirements. All wiring entry to the CCTV Assembly shall use watertight fittings. All wiring entry and exits shall be made at the side or underneath components; no exposed top entry or exits are permitted. This requirement extends to all enclosures, junction boxes, support arms, or any other externally exposed devices.

CAMERA LOWERING SYSTEM

Description

This work consists of furnishing and installing Camera Lowering Systems complete with all components as shown on the plans and as described herein. All work shall be accomplished in accordance with these provisions.

The Camera Lowering System shall include the following basic components:

1. Contact unit
2. Self-aligning divided support arm
3. Adapter for attachment to tower
4. CCTV Hybrid Composite Cable junction box at the top of the tower
5. Permanent mount lowering tool

Materials

The camera lowering system shall be designed to support and lower a standard closed circuit television camera, lens, housing, pan-tilt-zoom (PTZ) mechanism, cabling, connectors, and other supporting components without damage or causing degradation of camera operations. The camera lowering device and the tower are interdependent upon each other and thus, must be considered a single unit or system. The lowering system shall consist of a contact unit, self-aligning divided support arm, an adapter for attachment to a tower, and a camera connection box. The divided support arm and receiver brackets shall be designed to self-align the contact unit during installation and ensure the contact unit cannot twist under high wind conditions. The camera-lowering device shall withstand wind forces of 100 mph with a 30 percent gust factor using a 1.65 safety factor. The lowering device shall effectively operate within a temperature range of −40 to 191°F. The lowering device manufacturer shall furnish independent laboratory testing documents certifying adherence to the stated wind force criteria utilizing, as a minimum effective projected area EPA, the actual EPA or an EPA greater than that of the camera system to be attached. The camera-lowering device to be furnished shall be the product of manufacturers with a minimum of 2 years of experience in the successful manufacturing of such systems. The lowering device provider shall be able to identify a minimum of 3 previous projects where the purposed system has been installed successfully. The camera lowering system shall be [MG]2 Inc. model: CLDMG2-EXT-HYPIP-XX or Department approved equivalent.

The lowering device manufacturer shall furnish a factory representative to assist with the assembly and testing of the first lowering system onto the tower assembly. The Contractor shall ensure the Camera Lowering System Vendor coordinates with the Camera Tower Vendor to ensure proper integration of the Camera Lowering System and Camera Tower. At the time of future installation of the lowering device, the manufacturer shall furnish the Department documentation certifying that the Contractor has been instructed on the installation, operation and safety features of the lowering device.

General

All pulleys for the camera lowering device and portable lowering tool shall have sealed, self-lubricated bearings, oil tight bronze bearing, or sintered bronze bushings. The lowering cable shall be a minimum 1/8 in. diameter stainless steel aircraft cable with a minimum breaking strength of 1740 pounds with (7) strands of 19 gauge wire each.

The camera lowering system shall be capable of lowering the camera to the ground without contacting the tower structure or anything attached to the tower structure. A guide cable shall be provided to prevent interference with the tower structure. The guide cable shall be 5/32 inch diameter stainless steel and shall be a manufacturer provided component. The cable guide shall be installed per manufacturer's recommendations. The guide cable shall be mounted to minimize the impact on the camera's view of the roadway, and shall have the ability to be disconnected from the ground mounting point to maximize the camera's view.

All electrical and video connections between the fixed and lowerable portion of the contact block shall be protected from exposure to the weather by a waterproof seal to prevent degradation of the electrical contacts. The electrical connections between the fixed and movable lowering device components shall be designed to conduct 56,000bps RS422/485 or RS-232 data, and one (1) volt peak-to-peak video signals as well as the power requirements for operation of dome environmental controls.

The interface and locking components shall be made of stainless steel and or aluminum. All external components of the lowering device shall be made of corrosion resistant materials, powder coated, galvanized, or otherwise protected from the environment by industry-accepted coatings to withstand exposure to a corrosive environment. A weephole with screen shall be included on the underside of the weight box. A CCTV hybrid composite cable, specified elsewhere in these special provisions, shall be included for each camera lowering system.

Contact Unit

The suspension contact unit shall have a load capacity of 600 lbs with a 4 to 1 safety factor. There shall be a locking mechanism between the fixed and moveable components of the lowering device. The movable assembly shall have a minimum of 2 latches. This latching mechanism shall securely hold the device and its mounted equipment. The latching mechanism shall operate by alternately raising and lowering the assembly using the winch and lowering cable. When latched, all weight shall be removed from the lowering cable. The fixed unit shall have a heavy duty cast tracking guide and means to allow latching in the same position each time. The contact unit housing shall be weather proof with a gasket provided to seal the interior from dust and moisture.

The prefabricated components of the lift unit support system shall be designed to prevent the lifting cable from contacting the power or video cabling. The Design-Build Contractor shall supply a means of separating the power and video cabling from the lowering cable if required by the Design Documents or Engineer. The only cable permitted to move during lowering or raising shall be the stainless steel lowering cable. All other cables must remain stable and secure during lowering and raising operations.

The contact assembly block consists of DIN Housing containing thermoplastic insulation bodies that hold the individual contacts. Guide pins and guide bushings shall prevent mis-connections and provide accurate mating without relying on the contact pins to provide alignment. There shall be a minimum of 12 -0.06-in. contacts and 1-75 Ohm contact. The max current rating for each pin shall be at least 13 amps. The signal and power wires shall be crimped using an industry standard 8 point crimp tool. The video cable shall be 75 ohm coax not to exceed a length of 1000 feet. The cable loss with the connectors shall not exceed 0.8 dB per 100 feet at 5 MHz. The camera cable shall be made up with the contact assembly block in the factory and sealed with electrical insulating. The entire contact assembly block shall be sealed from external dust and moisture when in the mated condition by means of a gasket.

Lowering Tool

The camera-lowering device shall be operated by use of a permanent mount lowering tool. The lowering tool shall be provided with an adapter for operating the lowering device by a portable drill using a clutch mechanism. The clutch mechanism, but not the portable drill, shall be provided for each site. The lowering tool shall be equipped with a positive locking mechanism to secure the cable reel during raising and lowering operations. The lowering tool shall include the cable real and steel cable with sufficient length to lower the device to the ground level, plus 10 percent. The lowering tool shall be made of durable and corrosion resistant materials, powder coated, galvanized, or otherwise protected from the environment by industry-accepted coating to withstand exposure to a corrosive environment. Lowering tool shall be installed in a stainless steel, or Aluminum enclosure, rated NEMA 3R, mounted to the tower.

Manufacturer Testing

Prior to delivery of the camera lowering system, the manufacturer will test for the following:

1. Electrical continuity

2. Direct connectivity to ground for an open circuit of 120V.

The results of these tests shall be supplied to INDOT with each camera lowering system upon delivery.

Certification

The Design-Build Contractor shall provide a 916.02(b) Type C certification from the Vendor verifying the CCTV Hybrid Composite Cable was properly installed and tested before delivery to the Design-Build Contractor.

Warranty

The Design-Build Contractor shall provide a manufacturer’s warranty against defects in material and workmanship for a period of 5 years after final acceptance of each complete installation. The Design-Build Contractor shall include labor for removal and reinstallation of a failed unit. Warranty shall include complete connector assembly replacement for contacts failing due to water ingress and corrosion damage.

Construction Requirements

The Camera Lowering System shall be installed in accordance with the manufacturer’s instructions and per the plans. All materials shall be

installed in a neat and professional manner. All installation services shall comply with all warranty provisions and warranty contract maintenance services in accordance with these specifications. All installation services shall comply with all local and state electrical codes, and Motorola R-56 requirements. Installation of the Camera Lowering System shall be coordinated with INDOT to determine actual mounting height and azimuth. Typically, the Camera Lower System azimuth shall be perpendicular to the mainline lanes.

Existing camera lowering systems shall be removed and properly disposed of in a timely manner. Existing camera lowering systems that are removed shall become the property of the Design-Build Contractor unless directed otherwise by the Engineer.

CCTV HYBRID COMPOSITE CABLE

Description

This Section shall consist of furnishing and installing CCTV Hybrid Composite Cables for connecting CCTV Assemblies to the Camera Interface. Cables shall be a hybrid composite design that allows for both analog and digital data streams from current and future cameras of INDOT's choosing. INDOT will provide the exact specifications of the analog/digital hybrid cable design after the project has been awarded.

Materials

CCTV Hybrid Composite cables shall be a hybrid digital/analog composite cable that meets the requirements of the Treehaven Technologies camera interface, the CCTV assembly, and the Department's plans for future upgrades to a digital camera interface. This cable shall be the Treehaven Model: 13/C Composite Cable.

Applicable Specifications: UL/NEC/CEC CATV or CM. Flame Resistance: UL 1581 Vertical Tray.

Cables shall be a suitable length to allow installation between equipment without exceeding the minimum bend radius as specified by the manufacturer. Connectors shall be installed as necessary, and shall match the connector interface requirements for the equipment being connected and for the future equipment connections planned by the Department. Adapters shall not be acceptable.

Construction Requirements

CCTV Hybrid Composite cables shall be installed in accordance with the manufacturer's instructions and per the plans. All materials shall be installed in a neat and professional manner. All installation services will comply with all warranty provisions and warranty contract maintenance services in accordance with these specifications. All installation services shall comply with all local and state electrical codes, and Motorola R-56 requirements. Coordinate layout and installation of cables with other installations. Revise locations and elevations from those indicated as required to suit field conditions and as approved by the Engineer.

All unused connectors shall be made weathertight and neatly organized.

CCTV ASSEMBLY, CAMERA INTERFACE RACK MOUNT

Description

The Design-Build Contractor shall provide an interface for each camera assembly installed. This interface shall provide an assortment of power, data, local camera setup, and communications capability. At sites where space is not ideal for maintenance or the cabinet is not co-located with the pole a second camera interface shall be installed at the pole location.

Materials

The Camera Interface shall be a Treehaven RoadWay Vision Systems Field Box Model RVSFB120R for the rack mount and RVSFB120RNET for the field box or approved equivalent. The Design-Build Contractor must obtain approval from the Engineer prior to installing an equivalent device.

Contact information:

Treehaven Technologies, Inc.

282 Treehaven Avenue

Powell, OH 43065-8510

614-791-8843

The camera interface box shall meet the following specifications:

1. Input voltage 120 VAC 50/60 Hz
2. Input current 1.5 A
3. Dome power output 24 V, 50/60 Hz, 1.25 A
4. Heater power output 24 V, 50/60 Hz 5 A
5. Operational temperature range:

a. Rack Mount -10oF to +140oF

b. Field Box: -40oF to +185oF

6. Video input connector BNC, 75 Ohms
7. Monitor output connector BNC, 75 Ohms
8. Joystick RS-422 interface
9. Laptop RS-232 interface
10. Remote control RS-422 interface

The camera interface box shall have the following features:

1. Surge suppression on data, video and power supply lines
2. Manual switch to select local or remote PTZ control

a. The Rack Mount unit shall be mountable in a 19” wide rack

CAMERA TOWER, FOUNDATIONS, AND CONCRETE PAVING

Description

This Work shall consist of designing, furnishing, and erecting self-supporting camera towers, including the tower foundations and the concrete tower pad, for the type and height specified herein. All Work shall be accomplished in accordance with the PPA Documents including the Technical Provisions, Section 711 , and any other applicable sections of INDOT Standard Specifications, including 701, 702, and 703. The tower shall be supplied complete with all parts, fittings, and foundations; completely erected; lighted (as required); painted (as required); and ready for use by INDOT. Design-Build Contractor shall comply with all applicable Federal and Indiana Occupational Safety and Health Agencies (OSHA) regulations for this type of structure.

The towers will be used to support CCTV and microwave detectors for expressway surveillance along the Project ROW. The towers are located along I-65 Mainline. Camera towers shall be designed in accordance with the design data detailed below. Design-Build Contractor shall provide INDOT with structural designs and engineering Design Documents signed and sealed by a registered professional engineer in the State of Indiana for the camera towers, including the tower foundations. Included in the design of the foundations shall be a Geotechnical Design Report where the Design-Build Contractor is required to drill at least one structural boring at each foundation and provide a report signed and sealed by a registered geotechnical engineer in the State of Indiana with foundation recommendations. The design of the foundations shall be in accordance with the Project Standards. Basic tower components shall include the following:

1. Concrete base, piers, and foundation
2. Stone base
3. Structural members
4. Conduit(s), cables, cable supports, NEMA 34 enclosure and winch drive enclosures per design schedules
5. Transmission line ladder and hangers
6. Lightning rod and grounding cable
7. Grounding system
8. Safety climb devices – horizontal members, welded climbing loops, ladder, or bolt-type climb pegs for climbing and stainless steel cable type safety climb system
9. Trolley with removable traveler
10. Tower-mounted camera cabinets as required by this Project

The design shall comply with ANSI/EIA/TIA 222-G specifications.

The tower shall have a straight face design, such that the face width is uniform from the base to the top of the tower. The size of the steel rods shall be the only difference between successive tower sections.

During the construction and erection process and until completion of the tower, it is to be understood that all liability, either property damage or personal injury, connected with this project shall be the direct responsibility of the Design-Build Contractor.

The Design-Build Contractor shall warranty the complete tower against structural failure due to defective material or improper design or installation for a period of five years from the accepted completion date. This warranty shall include rust or any other mechanical defect in the tower, footings or anchors that would affect the normal life of the tower.

Design Data

The design criteria for camera towers shall conform to the EIA Bulletin ANSI/EIA/TIA-222-G or the latest edition.

Each tower shall be designed per American National Standards Institute/Electronic Industries Alliance/Telecommunications Industry Association (ANSI/EIA/TIA) -222-G structure class 2 and exposure class C. The ANSI/EIA/TIA-222-G topographic feature shall be designed per the most conservative topographic feature. The topographic feature for the towers shall be based on the latitude and longitude of each tower. The total load specified shall be applied to the structure in the direction that will cause the maximum stress in the various members.

The dead weight of the structure and all materials attached thereto shall be considered in the design.

The tower and footings shall be designed and constructed to maintain tower twist or sway limits as specified in EIA Bulletin ANSI/EIA/TIA-222-G or the latest edition. The twist and sway limits shall conform to a 90-mile-per-hour wind with no ice load. Design-Build Contractor shall verify with the manufacturer that specifications for selected antennas do not conflict with the tower deflection specification.

The tower shall support beacon(s), sidelights, and lighting equipment in accordance with the Federal Aviation Administration (FAA) requirements for each site.

An integral climbing device shall be furnished for the full length of the tower. The device steps shall be evenly spaced no further than 18 inches apart. This device shall be compatible with the safety climbing equipment described herein. The climbing device shall be part of the tower, not an external structure attached to the tower. The climbing device shall include a stainless steel cable climb safety device for the full length of the tower. The climb safety device shall use stainless steel mounting hardware. A solid climbing ladder may be considered as an alternate bid if an integral device is not available from the tower vendor. All applicable federal and Indiana OSHA regulations for climbing devices shall be complied with.

Towers shall be designed to incorporate an integral cable support system, enabling the use of snap-in hangers such as Andrew type 206706 snap-in cable support hanger.

Plans and Marking

Complete Plans and working drawings shall be supplied showing all of the necessary details to permit proper installation. All drawings shall show

the tower and its equipment as it is to be constructed and approved by the Department.

Plans are to include the tower base and anchors, concrete tower foundation, cubic yards of concrete, concrete finishing techniques, tower section details, torque stabilizer details, hardware, parts lists, and electrical wiring data.

All steel, except hardware, shall be marked with stenciled markings on metal tags wired to the members. The markings shall have a height of not less than 5/8 of an inch. The markings shall correspond with the markings on the manufacturer's erection diagrams (assembly drawings).

Materials

Solid steel rod members shall be used for tower construction to reduce drag coefficients, minimize wind and ice loading and high-corrosion resistance properties. In-factory welded construction shall be used as practical for easy in-field installation. Solid steel rod members shall be factory-painted as required or treated for corrosion protection in the factory.

All towers shall be labeled with a unique identification tag. The tag shall identify the manufacturer. In addition to the tower requirements above, the following items are required for specific tower locations, as referenced below. Design-Build Contractor shall provide a written certification that the manufacturer has designed the self-supporting tower and foundations in accordance with EIA/TIA standards. A Registered Professional Engineer in the State of Indiana shall stamp the tower and foundation designs. Design Documents shall be submitted in accordance with Design Quality Assurance, Quality Control and Oversight standards. Structural steel, cast steel, and steel forgings and bolts shall conform to specifications listed in "Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings," issued by the American Institute of Steel Construction (AISC), latest edition. Bolts and locking devices furnished shall be of high-strength steel and shall conform to the AISC specifications.

Steel tubes and/or pipe shall not be acceptable as construction material for this tower. Tower design shall include the following basic criteria:

1. Self-supporting lattice tower structure with triangular base. Camera towers shall have straight vertical legs to the top.

2. Solid steel rod members (i.e., no hollow components that can trap water).

3. Tower codes per current EIA/TIA standards.

4. Camera Tower Loading:

    a. Two cameras (maximum of one camera per tower face).

    b. Two cameras with lowering systems (maximum of one (1) per tower face). Camera lowering arms shall be designed at 70 feet from the base of the tower, with a maximum total equipment dead load of 600 pounds per camera.

c. Two 4-foot parabolic antennas (designed such that, regardless of tower height, the tower will be able to support the antennas mounted 2 feet from the top of a 120-foot tower to accommodate future expansion of towers less than 120 feet in height).

d. Two 30-inch by 30-inch by 48-inch tower-mounted camera cabinets mounted 5 feet above the base of the tower (conduit and 0.5-inch antenna cabling as necessary).

For friction-type connections, all high-strength bolts shall be installed in accordance with American Institute of Steel Construction (AISC) publication "Specifications for Structural Joints Using ASTM A325 or A490 Bolts," latest edition. All bolts shall require a nut locking device.

Solid steel members shall be used for tower construction to provide high-corrosion-resistance properties. In-factory welded construction shall be used for easy in-field installation. Solid steel members shall be factory primed and painted as required or treated for corrosion protection in the factory. All cotter pins used shall be made of a high-quality stainless steel to ensure long life. No substitutes shall be accepted.

Leveling of the tower at the base shall be done using only a steel plate of a suitable area and thickness.

All towers shall be labeled with a unique identification tag. The tag shall identify the manufacturer and shall include the tower identification address used in the Design Documents.

Manufacture and Workmanship

All manufacturing and workmanship shall be in accordance with commonly accepted standards of the structural steel fabricating industry.

All welding procedures shall be in accordance with the requirements of the appropriate AISC or AISI specifications.

Galvanizing Process

All steel material shall be galvanized after fabrication as described in the Electronics Institute Alliance (EIA) Bulletin ANSI/EIA/TIA-222-G or the latest edition as of the Setting Date.

Safety Climb System

A 3/8-inch, minimum, safety climb stainless steel cable system shall be installed on the tower, which meets EIA/TIA-222-G and OSHA-approved safety climb system standards, latest edition. A "trolley" attachment device or safety sleeve (a device that safely attaches to the safety cable with an emergency brake) with all necessary hardware and safety devices shall be furnished by Design-Build Contractor. The system shall include a removable traveler as well as all end-sleeves, connections, and standoffs (if Design-Build Contractor's proposed system is compatible with the Rohn Safety Climb). The climb safety system shall extend above the top of the tower, a minimum of 3 feet, to allow for continuous attachment of the climber while inspecting or performing maintenance on the top beacon light assembly.

If a rail system is used in lieu of a cable system, there shall not be a significant void or gap between sections of the rail to allow the trolley to fall out of the rail track or be hung up at the gaps or voids.

Foundation and Anchors

Pad and stem foundations and anchors shall be designed, taking into consideration the actual soil pressure from the geotechnical report for this specific site. The design shall take into account the resultant of all dead- and live-load reactions. Foundations and anchors shall be designed for the maximum combined dead and live loading expected.

In uplift, it shall be assumed that the base of the standard foundations or anchors with an undercut or toe engages the frustum of an inverted pyramid or cone of earth whose sides form an angle of 30 degrees with the vertical. Earth shall be considered to weigh 120 pounds per cubic foot (unless the soil analysis report dictates otherwise) and concrete 150 pounds per cubic foot. Weights of other materials shall be considered at the established values. The weight of all materials used to resist the uplift shall be calculated, and 50 percent of the actual value is added in order to provide a minimum safety factor of 2.

Foundation plans shall ordinarily show standard foundations and anchors as defined in this section. Where some modifications of the Project Standards are necessary because soil conditions are not normal, the manufacturer shall furnish a foundation design and Plan based on the actual soil conditions.

The concrete strength shall be in accordance with ASTM C94 and ACI 318 (latest edition) and shall test 4,000 pounds per square inch minimum in 28 days. Reinforcing bars shall be of intermediate grade 60 and in accordance with ASTM-A-615. All exposed concrete surfaces not formed shall be chamfered. Concrete tests shall be in accordance with ACI 301. Test two cylinders at the age of seven days and two cylinders at the age of 28 days. Reserve one cylinder for 56 days if the 28-day test does not meet the requirements. Three copies of the concrete test results, in report form, shall be supplied to INDOT.

Erection of the tower may begin 14 days after the concrete has been poured, provided the concrete test results are acceptable.

The tower base shall be carefully formed and poured so that the portion above grade level will present a neat and finished appearance. At least 6 inches of the base shall be above the final grade level. This base shall contain adequate reinforcing bars, neatly spaced, to provide adequate strength within the dictates of good engineering practices.

Construction Requirements

Prior to installation, Design-Build Contractor shall verify with INDOT the exact location, coordinates, and orientation of the CCTV camera before the placing of the foundations. The top of foundation for each tower shall be placed at the elevation indicated on the Plans. The tower orientation typically will permit mounting of the camera lowering system perpendicular to the mainline travel lanes such that it does not conflict with the microwave detector installation.

Grounding connections shall be made as soon as the first section is installed.

Concrete Paving

Design-Build Contractor shall pave the interior of the fenced area with 6 inches of non-reinforced Portland cement concrete (PCC). Paving shall be

slightly sloped to drain water away from shelter. The cost of this PCC pavement shall be incidental to the tower construction and shall be included in the cost of the tower.

Site Preparation

Design-Build Contractor shall provide a staked layout of the tower base and anchors, for the review and approval by INDOT three days prior to construction.

Design-Build Contractor shall be responsible for field adjustments of the tower location, including foundation and anchors. Any alteration to the locations on the Plans shall be submitted to INDOT for approval. Design-Build Contractor shall document changes on the Plans and submit revisions to INDOT.

Care shall be taken by Design-Build Contractor to preserve the lawn area around the tower construction area to the extent possible to minimize lawn restoration. Design-Build Contractor shall restore the grounds to their original condition. Upon completion and before the final inspection, all debris from the construction shall be removed and the site left in a neat and presentable manner.

Drilled Shaft Submittals

If drilled shaft foundations are selected by Design-Build Contractor then Design-Build Contractor shall be in accordance with INDOT RSP 728-B-203.

Tower Site Access

Design-Build Contractor shall provide driveway access to sites in excess of 15 feet from the edge of shoulder. This access shall be in accordance with a modified Class II driveway, with 12 inches of #53 stone, and appropriate pipe and end sections per the IDM.

FENCE AND GATE FOR TOWER SITES

Description

This Work shall consist of installing a barbed wire fence around the field tower sites and a gate for access into the fenced area.

Material and Construction Requirements

Fencing surrounding the field tower, including the barbed wire and gate shall be installed in accordance with 603. The fence height shall be minimum six feet and gate shall be sized to accommodate the largest equipment or vehicle requiring access. Gates shall be supplied with a gate latch capable of being padlocked when in the closed position. One padlock shall be provided per gate. Padlocks are to be as described elsewhere in these provisions. The fence, barbed wire, and gate shall be grounded according to these provisions. Gates shall be positively grounded to the grounding system.

GROUNDING ASSEMBLY

Description

This work shall consist of furnishing, assembling, and installing a grounding system as shown on the Plans and in accordance with these provisions and Motorola Standards and Guidelines for Communications Sites 2000 (R-56). Design-Build Contractor shall use a Registered Professional Engineer in the state of Indiana experienced in ground system design to design the grounding assembly and ensure that it is compatible with the site's ground system. Proof of such shall be submitted with the Final Design Documents in the form of a design drawing sealed by a Registered Professional Engineer in the state of Indiana. The ground system of each site shall achieve a resistance to earth of 4 Ohms or less, verified by three-point/fall-of-potential testing. An instrument designed specifically to measure the resistance of a point to each ground shall be used, and the instructions provided with the instrument shall be followed for proper measurement method. All measurements shall be recorded along with the location of each ground rod and submitted to INDOT.

Materials

The grounding assembly includes all items and incidentals necessary to successfully ground the tower sites, the surrounding chain-link fence, communication shelter, ITS equipment cabinets, generators, and panel boards as shown on the Plans.

Ground rods shall be copper-clad steel or solid copper as approved by INDOT. The rods shall have a minimum length of 10 feet and minimum diameter of 5/8 inch or greater, as otherwise required by National Fire Protection Act (NFPA) 70, Article 250-52. The actual diameter (greater than minimum diameter), length (greater than minimum length), and number of rods required may vary with site dimensions and/or as determined by an engineering study based on the soil resistivity profile and soil pH of the site. Electrolytic ground rods maybe used, if required by soil conditions, with the approval of INDOT. Refer to "Soil Resistivity Measurements" NFPA 70, Article 250-52, and NFPA 780, Section 3-13, for more information. The method of bonding grounding conductors to ground rods shall be compatible with the types of metals being bonded.

General

Ground rods shall be buried to a minimum depth of 30 inches below finished grade, where possible, or buried below the freeze line, whichever depth is greater. Where practical, ground rods shall be buried below permanent moisture level (NFPA 70, Article 250-52). Ground rods that cannot be driven straight down due to contact with rock formations may be driven at an oblique angle of not greater than 45 degrees from the vertical, or may be buried horizontally and perpendicular to the building, in a trench at least 30 inches deep. Refer to NFPA 70, Article 250-52 and NFPA 780, Section 3-13.1.5 for more information.

Ground rods shall not be installed more than 20 feet apart (or twice the length of the rod) and not less than 6 feet apart, per NFPA 70, Article 250-56.

The method of bonding grounding conductors to ground rods shall be compatible with the types of metals being bonded. Ground rods shall be free

of paint or other nonconductive coatings. See NFPA 70, Article 250-52 and NFPA 780, Section 3-13.1.

All grounding conductors outside of the communication shelters shall be bare tinned solid #2/ AWG copper wire or as shown on the Plans and shall meet the size requirements of NFPA 70, Article 250-66. Solid wire is required below grade to prolong longevity. For areas highly prone to lightning and/or areas with highly acidic soil, larger conductors shall be used, per Motorola R-56. Solid straps or bars may be used as long as the cross-sectional area equals or exceeds that of the specified grounding conductor.

Tower Grounding

A ground ring containing at least three equally spaced ground rods shall encircle the tower. The ground rod spacing shall not exceed 20 feet for 10-foot ground rods. The tower ground ring shall have a minimum diameter of 18 feet.

Self-supporting towers exceeding 5 feet in base width shall have at least four ground rods (ANSI T1.313-1997 and ANSI/EIA/TIA-222f). The ground rod spacing shall not exceed 20 feet for 10-foot ground rods. The tower ground ring shall have a minimum diameter of 23 feet.

Each leg of the towers shall be bonded to the tower ground ring using grounding conductors of #2 AWG minimum, bare tinned solid copper conductor. The vertical wire from the tower leg to the ring shall be insulated from earth contact for the first 12 inches or more by passing it through a polyvinyl chloride (PVC) pipe. This is to reduce the step voltage in the immediate vicinity of the tower.

In addition, a top-mounted lightning rod, extending above the topmost appurtenance, connected to a full tower length "down conductor" grounding cable shall be installed to provide a non-destructive path to ground for lightning contact with the tower structure. The down conductor shall consist of a #2 stranded copper cable attached and exothermically bonded to the uppermost tip of one tower leg, extending downward in a continuous run, exothermically bonded to the lower end of the same leg, then exothermically bonded to the grounding ring at the tower base. The down conductor shall be securely fastened, using two wraps of stainless steel banding, to the tower leg on which it is installed to prevent movement. The lightning rod shall be bonded to this down conductor. The tower ground bus bars shall be bonded to the “down conductor.”

Construction Requirements

All tower grounding Work shall be coordinated with the tower erection, fence construction, and other electrical Work associated with energizing the panel board within the communication shelter. All electrical components installed on the tower shall be electrically connected to the grounding system, including the PTZ mechanisms, cameras, and cable shielding. All construction and testing work shall conform to National Electrical Code (NEC) requirements, as well as these provisions. Design-Build Contractor shall provide INDOT with all test data and results.

The pH (hydrogen ion concentration) of the soil where a grounding electrode system is to be installed shall be tested before the system is installed. Acidic soils (pH below 7) can have a destructive effect on copper and other metals. In strongly acidic soils (pH of 5 or below), an

electrolytic ground rod system shall be installed to maintain the life expectancy of the system. The electrolytic ground rod system shall be by Harger or an equivalent.

The following requirements apply when installing grounding conductors:

Grounding conductors shall be run as short, straight, and smoothly as possible, with the fewest possible number of bends and curves. Refer to NFPA 70, Articles 800-40, 810-21, and 820-40.

A minimum bending radius of 8 inches shall be maintained, applicable to grounding conductors of all sizes, per NFPA 780, Section 3-9.5 and ANSI T1.313-1997. A diagonal run is preferable to a bend even though it does not follow the contour or run parallel to the supporting structure. All bends, curves, and connections shall be toward the ground location, rod, or ground bar (grounded end) of the conductor.

Grounding conductors attached to the tower, communication shelter, and above-ground structures, especially copper straps, are exposed to movement by wind and other physical forces that can lead to damage or breakage over time. The following requirements shall apply when installing grounding conductors on these structures:

1. The grounding conductor or its enclosure shall be securely fastened to the surface on which it is carried.

2. Grounding conductors shall be attached using the method recommended by the equipment manufacturer.

3. The fasteners shall not be subject to breakage and shall be of the same material as the conductor or of a material equally resistant to corrosion as that of the conductor.

4. Approved bonding techniques shall be observed for the connection of dissimilar metals.

5. Grounding conductors shall be securely fastened at intervals not exceeding 3 feet. Refer to NFPA 70, Articles 250-64(b), 810-21(c), and NFPA 780, Section 3-10.

All earthwork preparation and grading necessary for installation of the tower grounding system will be considered incidental to this Work. When the installation is completed, all disturbed portions of the construction area will be cleaned, and any excess excavation or other materials shall be disposed of in a timely manner. All final cleanup will also be considered incidental to this Work.

LIGHTNING PROTECTION

Description

Lightning protection shall include all devices necessary to provide safety for the equipment, cabinets, and service personnel by preventing damage caused by lightning. All poles and towers that are connected to an external power source (i.e., non-solar) and that exceed 15 feet in height shall be equipped with appropriate lightning protection. All ground wires shall be tinned copper.

Design-Build Contractor shall design a lightning protection system for each tower site and submit Plans in the form of a design drawing for approval by INDOT. The design shall be stamped by a Registered Professional Engineer in the state of Indiana. Submitted lighting protection plans must include a scaled tower site elevation view that shows all elements within the zone-of-protection provided by the lightning protection installed on the tower.

The system shall be an effective, aesthetically acceptable by INDOT, streamer-delaying lightning protection system designed to the standards of UL96 and UL96A. The system shall be designed in such a manner that it affords protection to the structure upon which it is installed in the event a direct lightning strike to the structure does occur. The system shall require no external power and shall require no extraordinary maintenance.

The following contain requirements that relate to this section:

1. Underwriters Laboratories, Inc., Lightning Protection Components, UL 96 and UL 96A

2. NFPA, Standard for the Installation of Lightning Protection Systems, NFPA 780

3. Motorola R-56, Motorola Standards and Guidelines for Communications Sites 2000, Chapter 6, External Grounding.

Where conflicts exist between the above-referenced documents and this document, the more stringent requirement shall prevail.

Materials

Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include Alltec Corporation, in Canton, North Carolina; Lightning Masters Corporation, in Clearwater, Florida; or East Coast Lightning Equipment, Inc., in Winsted, Connecticut.

The lightning protection system shall be the standard product of a manufacturer regularly engaged in the production of lightning protection equipment and shall be the manufacturer’s latest approved design. The manufacturer shall have a proven track record of successful lightning protection system performance. The equipment shall be UL listed and properly UL labeled.

The manufacturer or its authorized representative shall provide product and technical support.

All equipment shall be new and of a design and construction to suit the application where it is used in accordance with accepted industry standards and UL and NFPA requirements.

All lightning protection materials and components shall comply in weight, size, and composition with UL96 and NFPA780 lightning protection material requirements for the structure being protected. Components shall be constructed of material as specified by UL96 and UL96A for a system employing copper components, unless otherwise directed by INDOT or as necessary to prevent dissimilar metals from coming into contact. Class II materials shall be used on throughout the system.

Construction Requirements

Installation shall be accomplished by an experienced installation company that is listed with UL for lightning protection installation.

If installed on a metallic or an otherwise electrically conductive structure, the system shall be electrically bonded to the structure upon which it is installed through its mounting clamps and brackets, with additional bonding jumpers to grounded objects and to the structure, as required.

Design-Build Contractor shall coordinate its Work in such a manner as to not interfere with the normal operation of the structure upon which the installation is performed. Design-Build Contractor shall ensure a sound bond to the grounding system.

SIGNS

Dynamic Message Signs

The DMS shall meet the Project Standards by Department (refer to *Traffic Management Strategic Deployment Plan, Final Report, Indiana Department of Transportation, 2008*) for the signs located on this Project. All overhead DMSs shall be mounted perpendicular to and centered over the travel lanes for the best line of sight. Design-Build Contractor shall design the DMS installations to meet the pertinent state standards, MUTCD standards, on DMS controller and communications, maintenance with safe access, and operation on 24/7 schedules.

The overhead DMSs are LED (light emitting diode) displayed, full-matrix signs capable of displaying three lines of up to 21 characters each, with support structures and foundations in accordance with the AASHTO standards and pertinent State standards for DMSs.

The sign display shall have a minimum width of 127 pixels and a minimum height of 27 pixels.

Design-Build Contractor shall be fully responsible for design, structural calculations, fabrication, the installation of the DMSs, and sign structure and supporting foundations. Design-Build Contractor shall be responsible for the design, furnishing and installation of maintenance platforms, guide railings, or traffic barriers if within clear zones, as required by OSHA, Department TMC. Design-Build Contractor shall be responsible for all testing of DMSs, per NTCIP standards, to provide a fully functional DMS subsystem.

Design-Build Contractor shall furnish and install a permanent DMS mounted on a new structure. This Work will be done in accordance with Project Standards, except as modified herein. The sign messages shall be initiated by the advanced traffic management system (ATMS) software, or by a portable field control computer at the sign site for local diagnostics. Commands from the ATMS software shall be transmitted over Department communications infrastructure or a standard cellular connection using a wireless modem and service. Cellular communication is allowable for temporary communications. However, fiber communication is required as a final condition. All DMS equipment shall be housed within the sign housing; no external cabinets will be used. The DMS shall be NTCIP compliant as currently defined by the NTCIP *Object Definitions for Dynamic Message Signs Publication 1203* (including subsequent revisions).

Description

This Work shall consist of furnishing and installing a permanent DMS, complete with all components as shown on the Plans and as described herein.

The DMS shall be a full matrix LED sign with a walk-in enclosure housing using all modular, controller, electrical, and communication equipment. The DMS shall include the following basic components:

1. DMS
2. Walk-in enclosure
3. DMS controller, firmware, and software

4. Electrical end-equipment

5. Mounting hardware

6. Overhead DMS Box Truss, per Department Standard Drawings

General Requirements

The Design-Build Contractor shall furnish, install, and test all equipment and components necessary to provide full and complete ITS functionality in all respects, without additional expense to INDOT.

The Design-Build Contractor shall furnish one controller as an integral part of each DMS. The controller is to be mounted inside the DMS and connected to the AFP (provided by Design-Build Contractor) for communications back to the TMC.

The Design-Build Contractor shall demonstrate that the DMS functions and meets the requirements in these specifications.

The Design-Build Contractor shall provide all equipment required for testing of the DMS and DMS components included as part of the Work as an appurtenance to the electronic equipment included within this Project at no additional expense to INDOT.

National Transportation Communication for ITS Protocol Standards

NTCIP Definitions

NTCIP	Definition Terms
DMS	A DMS includes the sign display, controller, housing, and other associated field equipment. NTCIP standards (defined in two distinct sub-requirements, as below): If the access of the object is read-write, a management system shall be able to set the object to any valid value as defined by the syntax and description fields (except that the value of "other" need not be supported when such a value is defined) and the indicated functionality shall be provided. The value indicated by the object (e.g., in response to a "get"), regardless of the access, shall reflect the current condition per the rules specified in the object's description.
Management System	A computer system used to control a DMS. This includes any laptop software used for field control as well as the central control software.
NTCIP Component	A DMS or a management system
NTCIP System	A management system, plus the various DMSs controlled by the management system

Dynamic Message Sign Manufacturing and Design Standards

DMS manufacturers shall comply with the Project Standards including the most current version, as of the Setting Date, of the following standards:

1. High-voltage wiring: High-voltage components and circuits (120 volts alternating current) shall be wired and color-coded per the NEC.

2. Environmental: The display and all display components shall conform to NEMA TS-2 Section 2 Environmental Standards.

3. Shock/Vibration: The display and all display components shall conform to NEMA TS-2 Section 2 shock/vibration tests.

4. NTCIP: Refer to NTCIP Section.

5. NEMA TS 4 Hardware Standards for DMS with NTCIP Requirements.

Materials

All electrical equipment shall operate within the range of environmental conditions specified herein and come with warranties. The warranties shall receive the approval of INDOT prior to the use of the respective equipment.

Weight and Dimensions

The maximum static weight of the DMS, including all internal and external components and mounting devices and members shall not exceed 4,500 pounds. In addition to the static weight, a live load of 600 pounds for maintenance personnel and equipment is to be accounted for in the structural analysis. The approximate outside dimension of the DMS enclosure shall not exceed 28 feet wide by 9 feet 10 inches high by 4 feet 1 inch deep.

Display Characteristics

The DMS shall consist of interchangeable LED modules arranged to provide a full matrix display. The full matrix display shall provide three character lines each 20 characters long, separated vertically by three blank pixel rows. Horizontal spacing between characters shall be a minimum of one pixel column. Each display module shall consist of one or more pixel matrices. Each pixel matrix shall form characters that are 18 inches in height.

The sign display shall have a minimum width of 127 pixels and a minimum height of 27 pixels.

The width of the borders on the display shall be equal and not less than 12 inches. Legibility of displays shall include daylight hours with direct sunlight on the face and behind the DMS.

Minimum clear visibility and legibility distance for the sign shall be 900 feet at an eye height of 3.5 feet within a 10° cone of vision about the optical axis under all weather conditions, except heavy rain, fog, or snow.

The display shall not perceivably brighten due to stray headlights shining on the photocells at night.

Basic Dynamic Message Sign Functions

A character set shall be provided and shall consist of at least the following:

1. All 26 capital letters of the alphabet

2. All digits 0 through 9

3. Arrows pointing to the eight primary compass points

4. Punctuation marks ($□ + - = . , ‘ & / \ ( ) * ! ; : “ ” % # ? < > @ ~ ^ [ ] |)

5. Sequential arrow

6. Standard font (7x5 pixels per character)

7. Double stroke font (7x7 pixels per character)

8. Condensed font (7x4 pixels per character)

9. Expanded font (7x6 pixels per character)

10. Two additional user-defined fonts for a total of six fonts (standard, double stroke, condensed, expanded, two user defined)

Each sign shall be able to display static, multi-frame, or flashing messages:

1. Static Message: The chosen message shall be displayed constantly on the sign face until the sign controller is instructed to do otherwise.

2. Multi-frame Message: The chosen message shall display up to four different frames alternately at durations separately controllable in 0.1-second increments from 0.1 seconds to 25.5 seconds.

3. Flashing Message: A flashing capability shall be possible by blanking the LEDs. The parameters controlling the flashing rate shall be operator-selectable from 0.1 seconds to 9.9 seconds, in increments of 0.1 seconds.

Display Modules

The sign display shall be created by interconnecting several individual and interchangeable display modules. Each display module shall be capable of displaying a minimum of one 18-inch character, but not more than three 18-inch characters. The replacement of a complete display module shall be possible from the interior of the sign enclosure without the use of any special tools. Display modules shall be identical and interchangeable in all signs provided for this Project. Interconnection of modules shall be through connectors only. Each pixel shall have its optic axis oriented perpendicular to the sign face. Pixels shall be attached to the display module with a secure fastening system.

Pixels

Pixel columns and rows shall be perpendicular. The horizontal and vertical spacing (the pitch) of the pixels on center shall be identical on each display module and between all display modules in the DMS.

Each pixel shall contain either one or two strings of LEDs. Pixels containing only one string shall have a minimum of six LEDs and be designed such that the failure of one LED shall not affect the operation of the rest of that string or any other string. Pixels containing two strings shall

contain a minimum of three LEDs per string and be designed such that the failure of an LED in one string shall not affect the operation of any other string or pixel.

Each pixel shall have a total brightness of 40 candelas per pixel at 20 milliampere as the sum from all LEDs in each individual pixel. The total on-axis (0 degrees horizontal, 0 degrees vertical) luminance intensity of the sign will be a minimum of 8,000 candelas per square meter. All pixels shall have equal color and on-axis intensity. The method used to provide the brightness, equal color, and intensity shall be included in the shop drawing submittals and approved by INDOT. Pixel brightness shall be tested and documented by a third-party lab. This documentation shall be submitted to INDOT for approval prior to shipping the sign.

Each pixel shall have a device attached to the printed circuit board (PCB) to hold and protect the LEDs. These devices shall do the following:

Hold the LEDs to within 0.5 degrees of being perpendicular to the display modules.

1. Prevent the LEDs from being crushed or bent during handling.
2. The LEDs shall be protected such that there is no contact with them when the display module is handled or dropped.
3. Protect the LEDs from damage when the display module is laid on the front surface (the side on which the LED lamps are located).
4. Be easily removable from the display module PCB without any specialized tools.
5. Not put any stress on the LEDs due to differentials of expansion and contraction between the device and the LEDs over the temperature range herein specified.
6. Not become loose or fall off during handling or due to vibration.
7. Not block airflow over the leads of the LEDs.
8. Not block the light output of the LEDs at the required viewing angle.
9. Be black in color to maximize contrast.

LEDs

The LEDs shall be amber in color and manufactured by Avago Technologies, Nicha Corporation, Sander, Agilent, or Toshiba Corporation, and be of the same make and model and all traceable to the manufacturer. LEDs will have a 30-degree viewing angle. LEDs shall have a typical luminous intensity of 4.2 to 7.2 candelas per individual discrete LED when driven at 20 milliamperes. The light emitted by the LED display shall be an amber color, with a peak wavelength centered at approximately 590 nanometers +2 nanometers. LEDs in an individual sign will be from no more than two consecutive “bins” for either color or light intensity levels. The DMS manufacturer will perform the color/intensity sorting of individual LEDs, and they will be distributed consistently from pixel to pixel. The luminous

intensity of the highest- and lowest-appearing pixels will be measured, and the intensity ratio (L1/L2 where L1 > L2) between the two shall be less than 3:1. LEDs shall have no less than 50 percent of the normalized intensity at their respective 30 degree viewing angle.

Each LED shall be individually soldered to the boards. Each LED shall be mechanically inserted onto the appropriate LED matrix module and wave-soldered. A conformal coating shall then be applied to both sides of each PCB to provide moisture and mildew resistance. LEDs that are surface mounted or through-hole with standoffs will not be allowed.

LEDs shall be nominally rated for 100,000 hours of operation under field conditions, which shall include operating temperatures between 29.2 degrees Fahrenheit and 165.2 degrees Fahrenheit.

The brightness of each LED shall be measured in accordance with the International Lighting Commission (CIE) Test Method A, as described with the CIE 127-2007, Technical Report: Measurement of LEDs. The LED brightness and color bins that are used in each pixel shall be provided to INDOT for approval.

Certification shall be provided with the shop drawing submittals from the LED manufacturer that demonstrates the LEDs were tested and binned in accordance with CIE Test Method A. This certification shall be provided to INDOT prior to site delivery.

Optical Performance

Operating contrast values between 6 and 25 shall be demonstrated for each lighting condition given the following definitions:

Luminance =	The luminous intensity of the 35 pixels The area of the block containing the 35 pixels including the background
Daytime Contrast =	(Luminance On - Luminance Off)/Luminance Off
Where the ambient light is simulated by a solar source simulator placed 10 degrees off the horizontal axis in front of the sign when measured on-axis to the center of the sign face giving a luminance of 40,000 lux on the sign face.	

Electronics

All DMS electronics shall be solid state technology and, with the exception of the PCBs, shall be commercially available, easily accessible, replaceable, and removable using conventional electronic repair methods. Moving parts shall be minimized where practical. All electronic and electrical components used in the LED display or DMS controller or other digital control devices shall be UL or Electronic Testing Laboratories (ETL) listed. This includes power supplies, wiring, and wiring accessories. Copies of UL or ETL product cards shall be provided to INDOT prior to site delivery to document the listings. All data and low power connections will be accomplished via positive locking devices.

All workmanship shall comply with ANSI/IPC A-610D Class 2 titled, "Acceptability of Electronic Assemblies," and ANSI/IPC-7711/21B titled, "Rework Modification and Repair Electronic Assemblies."

All PCBs, except for the LED motherboard, power supply PCBs, and controller PCBs, shall be completely conformal coated with 0.010-inch minimum thickness silicone resin. The LED motherboard shall be completely conformal coated, except at the pixels on the front of the PCBs, with 0.010-inch minimum thickness silicone resin. The material used for the PCB coating shall meet the military specification MIL-I-46058C Type SR.

The LED pixels shall be directly driven using pulse width modulation (PWM) of the drive current to control the display intensity. This LED driver circuitry shall vary the current pulse width to achieve the proper display intensity levels for all ambient light conditions. The drive current pulse shall be modulated at a frequency high enough to provide flicker-free operation and a minimum of 200 brightness levels. The power supplies shall be designed such that one supply may fail and the sign display will still be supplied with sufficient power to run 100 percent of the pixels at 100 percent duty at 60 degrees Celsius. The power distribution system shall connect each display module to all power supplies and shall minimize voltage drop over the face of the sign. Multiplexing drive circuits shall not be used. The LED display manufacturer shall supply the schematic of the display to document the LED drive mode used.

The current provided at maximum brightness shall be easily adjustable between 15 milliampere and 30 milliampere in 1 percent increments. This adjustment will be altered occasionally over the life of the sign to offset the dimming of the LEDs as they age. LED brightness shall be controlled or adjusted in three ways: locally using the sign controller, remotely from the ATMS using the sign controller's serial communications port, and automatically via a closed-loop ambient light monitoring circuit. Once the LED brightness is set or adjusted, intensity shall not fluctuate or flicker due to sudden ambient light level changes caused by weather (i.e., moving cloud cover) or vehicle headlights. It is not necessary that maximum brightness be remotely controlled. Upon installation, Design-Build Contractor shall set the maximum brightness current to 20 milliampere.

The sign controller shall continuously measure all LED module power supply voltages. The sign controller shall provide these voltage readings to the ATMS or remote laptop when polled.

Maintenance

All DMS equipment components, modular assemblies, and other materials located in the DMS housing shall be removable, transportable, and capable of being installed by a single technician accessing the sign from inside the walk-in enclosure.

Miscellaneous Requirements

The presence of ambient magnetic or electromagnetic fields, including those created by any components of the DMS subsystem, shall not interfere with the performance of the signs.

The rated life of all components, except LEDs, fans, filters, and equipment not normally furnished with the DMS, shall be a minimum of 20 years under 24-hour-a-day operation.

Equipment and accessories shall be, essentially, the standard cataloged products and of the latest design of manufacturers regularly engaged in production of such equipment and accessories for at least five years.

Differential expansion of the sign enclosure, sign face, and the display panel shall not cause damage to any of the components.

Walk-In Enclosure

The DMS walk-in enclosure (housing) shall be furnished and installed in this Project and be designed integral to the DMS. The DMS housing, including its front-face panels, shall be a NEMA type 3R, as described in the latest edition of the NEMA Standards Publication 250. The bottom of the sign shall be horizontal, and all sides shall be vertical. The top shall slope to the rear to completely drain rainwater from the roof. Sign housings shall be constructed of aluminum alloy 3003-HI4 or 5052-H32, and shall not be less than 0.125 inches thick. Seams shall be continuously welded. Framing structural shapes shall be constructed of aluminum alloy 6061-T6 or 6063-T52. Non-corrosive materials shall be used where possible and corrosion protection shall be provided between dissimilar metals. Sign housings shall be cleaned and de-oxidized after welding.

To allow for the vacuum effect of the passage of large trucks, the sign face shall be designed for and shall withstand a negative (outward) pressure of 50 percent of the design inward wind pressure. Gasket material, where needed, shall be impervious to moisture, smog, and salt spray. If neoprene is used, the mating surface shall be covered with a silicon lubricant to prevent sticking to the mating metal surface.

The walk-in enclosure shall be designed such that the top of the display face (the surface that faces approaching traffic) is tilted 3 degrees toward traffic. The top plane of the housing shall be sloped 0.5 degrees toward the back of the housing. The rear plane of the housing shall remain vertical, and the interior walkway surface shall remain level (horizontal).

The manufacturer’s name, month, and year of manufacture shall appear on the inside of the DMS housing. No logos or names of manufacturers shall appear on the outside of the housing.

Painting

The front of the sign enclosure will be coated with a semi-gloss black polyvinylidene fluoride (PVDF) protective coating. This coating will be designed to have a minimum of 10-year color retention and chalk resistance. All finish coatings shall be resistant to chipping, impacts, weather, scuffs, corrosion, and bacteria for a minimum of 10 years. All other surfaces shall be left their natural finish or unfinished aluminum.

Environmental

The sign shall be constructed to present a clean, neat appearance, and the equipment located therein shall be protected from moisture, dust, dirt, and corrosion. Sign enclosures shall contain small weep holes for draining moisture that accumulates in the signs from condensation. Weep holes shall be designed to prevent the entrance of insects and shall have snap-in drain filter plug inserts. The filter plug inserts shall be replaceable.

Sign Attachment Members

The sign shall be attached to the sign structure with I-beams or Z-bar extrusions. The number of I-beams or Z-bars needed and the method of attaching the I-beams or Z-bars to the sign housing and sign structure shall be as required to conform to the Project Standards. The housing shall be designed to accommodate mounting on the rear vertical plane. All structural hardware and mounting bracket hardware will be stainless steel or galvanized high-strength steel and appropriately sized for the application. Mounting brackets will be attached to the DMS using direct-tension indicators to verify that mounting hardware is tightened with the proper amount of force. The attachment method shall be certified by a Registered Professional Engineer. The DMS shall be furnished with all required hardware for attachment to the sign structure. Alternative mounting methods will be considered, and Design-Build Contractor shall submit final mounting plans to INDOT for Design Review.

Lifting eyes or the equivalent shall be provided for moving and mounting signs. The DMS housing shall be designed such that the DMS can be shipped and temporarily stored without damage or undue stresses prior to installation on the overhead support structure.

Maintenance and Repair

Design and construct the walk-in housing so that all maintenance and repair is performed from within the DMS housing, with the exception of structural members and components thereof. The minimum clear distance from the interior rear wall of the DMS housing to the closest display components shall be 2 feet. This free space shall be maintained across the entire interior of the sign housing. Structural members shall be designed and positioned so as to not be an obstruction to free movement of maintenance technicians throughout the interior of the housing.

Include in the housing an internal incandescent lighting system of at least six fixtures to provide maintenance personnel with a minimum of 35 foot-candles of light measured at the floor, evenly distributed, provided by ceiling or top of wall mounted incandescent or compact fluorescent lights utilizing a cold-weather ballast within each sign housing. Locate two 3-circuit control switches inside the DMS housing for the lighting system, within easy reach from outside the DMS housing through the entryway. The sign housing and display panel shall be designed to be sufficiently “light tight,” such that during night-time maintenance activities, no internal lighting shall be visible or distracting to motorists.

The DMS housing shall include a minimum of three 15 Amp, 120 volts alternating current duplex electrical outlets, with ground fault circuit interrupters, for use by maintenance personnel. The duplex outlets are to be mounted on the back wall of the DMS, distributed evenly within the housing. All power runs inside the housing shall be protected in intermediate metallic conduits attached to the inside of the sign case.

Interior Walkway

The interior of the walk-in enclosure shall provide a minimum clear width of 2 feet and a minimum clear height of 6 feet through the length of the walkway to allow maintenance personnel free movement and working space. The interior walkway of the DMS shall be non-slip and able to support a minimum of a 500-pound load per linear foot and will be constructed of

multiple removable panels. The walkway's top surface shall be free of obstructions that would present a tripping hazard to maintenance personnel.

Personnel Access

The DMS housing shall have two vertically hinged doors, one on each end of the sign. The DMS housing doors shall be rain-tight/dust-tight. Doorway openings shall be a minimum of 6.5 feet in height and a minimum of 2 feet in width. The doors shall use a Corbin Lock Number 2 and shall be furnished with a minimum of one number 2 key. The DMS doors shall open to the exterior of the DMS and have a stop to retain the door in its fully open position while workers are inside the sign.

The latching/locking mechanism shall include two handles: one on the interior of the housing such that a person with no key and no tools cannot become entrapped inside the housing and another on the exterior of the housing with a key lock.

Cable Access

Provide a cable entrance for AC power as described herein. Conduit shall enter the rear exterior wall (facing away from traffic) of the sign case through a 90-degree bend in the conduit. The attachment point between the conduit and sign case shall be sealed on both sides of the sign case with a neoprene gasket or other approved material such that no moisture, condensation, or light can penetrate the seal.

Attach two junction boxes to the interior wall of the sign case: one to receive the AC power and one the communications cables. The junction box for the communications cable shall be 6 inches by 6 inches by 2 inches and labeled on the outside "COMM." The junction box for the power cable shall be labeled on the outside "AC POWER." All entries and exits from the junction boxes will be made via conduit. Approximately 2 feet of cable slack shall be coiled in the junction boxes. Conduits leading from the junction boxes to the lighting panel and the AFP shall also be provided.

Sign Display Cover

The sign display cover is attached to the front of each sign case and is a weatherproof assembly that presents an unobstructed view of the sign display.

The DMS shop drawings submitted by Design-Build Contractor shall demonstrate the technique employed to minimize glare, reduce solar heat gain on the LEDs, and increase sign contrast in all ambient lighting conditions.

Compose the sign display cover of a series of clear-formed segments that, when placed side by side, form a complete face. Each display cover segment shall be of a size and weight that can easily be handled by maintenance personnel for replacement or cleaning. The sign display covers and display modules shall be constructed to allow all service operations from inside the sign case. The cover shall not be damaged by sign vibration or the positive and negative pressures resulting from changes in atmospheric conditions or the passing of large trucks.

This includes cleaning the outside of the window by tipping the modules and sign face inward. The removal of any combination of windows shall not alter the structural integrity of the sign case.

The clear lens panels shall be made of polycarbonate. Polycarbonate shall contain an ultraviolet (UV) light inhibitor, which protects the LED display matrix from the effects of UV light exposure and prevents premature aging of the polycarbonate itself. Polycarbonate sheets shall have the following characteristics:

1. Tensile Strength, Ultimate: 9,000 pounds per square inch
2. Tensile Strength, Yield: 9,300 pounds per square inch
3. Tensile Strain at Break: 125 percent
4. Tensile Modulus: 330,000 pounds per square inch
5. Flexural Modulus: 330,000 pounds per square inch
6. Impact Strength, Izod (1/8 inch, notched): 17 foot-pounds per inch of notch
7. Rockwell Hardness: M75, R118
8. Heat Deflection Temperature Under Load: 264 pounds per square inch at 270 degrees Fahrenheit and 66 pounds per square inch at 288 degrees Fahrenheit
9. Coefficient of Thermal Expansion: 3.9X10-5 in/in/F
10. Specific Heat: 0.30 British thermal unit per pound per degree Fahrenheit
11. Initial Light Transmittance: 85 percent minimum
12. Change in Light Transmittance, 5 years exposure in a southern latitude: less than 5 percent
13. Change in Yellowness Index, 5 years exposure in southern latitude: less than 5 percent

The display cover and all associated parts, such as fasteners, shall be captive so that they cannot fall to the roadway. The windows shall be dust-proof and shall not leak when sprayed with water from any angle by a garden hose at a pressure equivalent to rain in a 90-mile-per-hour wind. The window frame(s) shall have a continuous closed-cell neoprene gasket around the entire perimeter. Horizontal portions of the gasket shall be supported by a channel. The gasket shall be at least 1 inch wide and 0.375 inches thick. The mating surface of the gasket shall be treated with silicone lubricant so that it does not stick. The sign face display cover shall be designed to minimize bowing.

Heaters and Fans

Signs shall contain thermostatically controlled fans and electric heating elements to prevent condensation on the inside of the display windows. A humidistat and thermostat shall also be included to activate the fans and electric heaters at user-selectable settings to control temperature and humidity for the display window and sign case. The defogging system shall be capable of substantially removing condensation from a completely fogged window within five minutes.

Vented thermostatically controlled fans shall be used to circulate the air inside the enclosures for cooling. Cooling fans shall turn on when the internal DMS air temperature reaches 30 degrees Celsius. Fans shall keep the back side of the display modules below 60 degrees Celsius when the outdoor temperature is 40 degrees Celsius, the face of the sign is in full sun, and 50 percent of the pixels are illuminated, drawing 20 milliamperes of current. The ventilation system shall achieve this performance despite the failure of any single fan. The fans shall be installed so as to either "blow" air into or out of the sign case. Air inlets shall have louvers to keep out rain, rustproof screens to keep out insects, and replaceable 2-inch air filters to keep out dust. The filters shall be available from multiple manufacturers and shall be located to facilitate replacement. Exhaust vents shall be screened and have movable louvers that are closed when the fans are not running.

The LED modules and electric equipment shall be protected by a fail-safe, back-up fan control system in the event of an electronic fan control failure or shutdown of the DMS controller.

Heaters shall operate from a 240-volt, 60-hertz, single-phase AC power. Fans shall operate from 120-volt, 60-hertz, single-phase AC power.

Fire Extinguisher

Furnish and install a 5-pound standard BC powder fire extinguisher by the rear door. The fire extinguisher shall have squeeze grip operation. The fire extinguisher shall be supplied complete with a wall bracket and shall be mounted on the internal wall of the sign enclosure within easy reach of the door opening.

The fire extinguisher shall include positive on/off operation, pull-pin safety locks, a waterproof stainless steel gauge, and an anodized aluminum valve.

Interference

The dimming circuit and DMS power system shall have electrical devices installed to minimize radio frequency interference (RFI) noise generated by the DMS both on the power line and radiated by sign circuitry.

DMS Controller, Firmware, and Software

Furnish, test, and install a DMS controller, firmware, and software compatible with the communications protocol provided by INDOT, at each DMS site shown on the Plans. Furnish, test, and install the auxiliary equipment and wiring required to complete the system testing. The DMS shall be capable of receiving communications from the server located at one of Department's TMCs and displaying messages by illuminating the LEDs to form legible words and graphics. Provide all equipment and materials needed to interconnect and interface the controller to the sign, including cables and connectors. Provide controller software that is consistent with the operational requirements and communications protocols.

DMS controllers shall have the following features:

1. Communications Ports. The DMS controller shall be able to receive instructions from and provide information to the ATMS network. There will be ports available for both local and remote operation of the DMS.

The DMS sign controller shall contain a minimum of one 10/100Base-T Ethernet communication port. This port shall be available for optional use for communicating from the ATMS to the DMS sign controller when an Ethernet network is available. The Ethernet port shall have a standard RJ45 connector.

The DMS sign controller shall contain a minimum of two NTCIP-compatible RS-232 communications ports. These ports shall support multiple communication interfaces, including direct null-modem (for local laptop control), dial-up and leased-line modems, radio systems, cellular modems, and fiber-optic modems. The RS232 ports shall all have standard DB9M connectors.

2. Microprocessor. The DMS controller shall be a solid state microprocessor.

3. Internal Clock. The controller shall have an internal clock that will satisfy the following minimum requirements:

   The internal clock shall obtain its timing reference either from a crystal or from the 60-hertz frequency of the power input line. For internal clocks obtaining its timing reference from the 60-hertz power line frequency, the timing reference shall be crystal controlled in the absence of AC power. In either case, the clock shall be accurate to within 15 seconds per month.

   The internal clock shall have both permanent and changeable memory. The permanent memory shall be in the form of plug-in programmable read-only memory (PROM) integrated circuits. It shall contain the software for performing the required timing functions. The changeable memory shall be in the form of random access memory (RAM) integrated circuits with a lithium battery back-up that retains the data in memory for a minimum of one year following a power failure.

   The changeable memory shall contain the current time in the form of year, month, day of month, hour of day, minute of hour, and second of minute.

   The correct time shall be entered into changeable memory as a function of the year, month, day of month, hour of day, minute of hour, and second of minute. Hours of the day shall be entered in 24-hour (military) format.

   The internal clock shall automatically compensate for leap years. The dates and times on which daylight-savings-time changes take place shall be user-programmable. The programming for daylight-savings-time changes shall be accomplished in such a manner that reprogramming each year is not necessary. Once set, the internal clock shall automatically adjust the hour of the day for daylight-savings-time changes.

4. Stored Messages. The DMS controller shall be capable of storing a minimum of 100 messages in non-volatile memory, each message consisting of up to three phrases and each phrase consisting of up to three full lines of text.

14. Default Message. The DMS controller shall be designed to blank out the sign in the event of a power failure.

15. Message Speed. The LED display shall update instantaneously with no shifting, scrolling, or other visual disturbance apparent to the motorist.

16. Controller Failures and Loss of Power. In the event of a controller failure, any displayed message shall be blanked out. The controller's operating system shall reside in non-volatile memory and shall reinitialize automatically at power-up and run without operator intervention. In the event of power outage, the clock shall re-start with the correct time (e.g., GPS or crystal clock) on the restoration of power.

    During the period of time that the controller is attempting to automatically recover from a controller failure, and until such time that the initialization process is complete, no messages shall be displayed on the sign.

17. Pixel Failures. The controller shall determine how many pixels are not turning on, how many pixels are not turning off, and the number of modules that have failed. This information shall be reported to the DMS controller.

18. LED Temperature Monitor. The sign controller shall monitor the temperature of the LED circuit board and shall reduce light output (DC forward current) when the temperature exceeds unacceptable thresholds. At least three temperature levels, set via the system interface, shall be supported, which will result in increasingly lower output to the LEDs. The sign controller shall perform an automatic sign shutdown when the temperature exceeds an absolute threshold. The sign controller shall use an analog to digital converter to capture the current LED temperature. Current temperature shall be reportable to the ATMS or portable computer via the sign controller interface. The temperature sensors shall be equally spaced to cover each end and the middle of the sign.

    The DMS controller shall continuously measure all LED module power supply voltages and be able to report those voltages both locally and remotely to the ATMS.

Physical

The DMS controller and all of its associated equipment, cables, connectors, and materials shall be designed, constructed, and positioned so that all maintenance and repair is performed from inside the walk-in enclosure.

All DMS controller equipment, components, modular assemblies, and other materials located in the walk-in enclosure shall be removable, transportable, and installable by a single technician.

Provide space inside the walk-in enclosure for the installation of the AFP and junction boxes. The area provided for the installation of this auxiliary equipment shall clearly be shown in Design-Build Contractor's

submittal of the DMS shop drawings. Conduits shall be provided between the DMS controller and equipment racks to the AFP and cabinet interface panel as necessary for a neat and orderly installation of cables and connectors.

The DMS equipment, components, and housing shall be designed and constructed for ease of maintenance. A single technician shall be able to remove and replace any modular assembly under adverse conditions in under 15 minutes. All electronic subassemblies shall be accessible and easily replaced by using plug-in or connector-based subassemblies. Any required configuration jumpers shall be clearly marked.

DMS controller circuit breakers, fuses, switches, and indicators shall be readily visible inside the walk-in enclosure.

All assemblies and panels shall allow air circulation through the top and bottom, unless specifically called out otherwise. Assemblies shall be fabricated of 0.0625-inch-minimum-thickness aluminum or stainless steel sheet. The metal surface shall be treated with clear chromate.

Software

The application software shall be supplied for local operation of the DMS controller, and it shall be NTCIP compliant. Provide a licensing agreement that facilitates unlimited use within INDOT or authorized maintenance contracts. Provide software with the following minimum capabilities:

1. Verify, set, and change the time on the internal clock.
2. Verify, enter, change, and delete dates and times for daylight savings time changes.
3. View, enter new, edit existing, and delete entries in the event schedule.
4. Verify, enter, modify, and delete password protection codes.
5. Diagnostic routines capable of testing full sign operation.

Display tests shall include but not be limited to the following:

1. All pixels on
2. All pixels off
3. All pixels on and off alternately
4. Sequence through each column
5. Sequence through each row
6. Sequence through the entire character set
7. Display immediate messages on the DMS entered through the portable field control computer’s keyboard.
8. Mimic both diagnostic and operator-generated messages sent to the DMS display on the portable field control computer’s display in

pixel matrix format identical to that of the sign being controlled.

9. Operator selection of dimming levels.

Exerciser

The manufacturer shall supply two compiled, latest versions of the FHWA, NTCIP exerciser with the manufacturer's MIB. One copy shall be sent to Jessica Kruger, Indiana Department of Transportation, and one to the manufacturer's representative. .

Dimming System

The DMS controller shall incorporate a means of changing the lighting level provided by the LEDs automatically in response to ambient lighting conditions at each sign location as detected by the photocell system, and remotely in response to commands received from the software. A light sensing system shall be used to detect lighting conditions between ranges of 2 to 20,000 lux. Provide photoelectric cells integral to the DMS. These devices shall direct the DMS controller to modify the intensity of the light produced by the pixel elements. Locate the photoelectric cells such that they are easily accessible for maintenance. Seal photoelectric cells using twist-lock-type receptacles or other approved receptacles suitable for this application. Three replaceable photocells shall be located on the DMS enclosure and positioned to sense the ambient light on three axes of the DMS in such a manner to provide the information necessary to allow the controller to adjust the light levels of the DMS to maintain optimum visibility at sunrise, sunset, and other abnormal lighting conditions.

Provide all wiring and equipment necessary for the operation and interconnection of the photocell system and the light level output control circuit. Incorporate the light level output control circuit in the DMS controller. The circuit shall consist of solid state or other approved methods for control of the photoelectric system. The system shall provide a minimum of eight settings that are both locally and remotely settable.

Electrical End-Equipment

Design-Build Contractor shall establish electric service accounts in INDOT's name, as appropriate. Each DMS sign shall have a lighting panel mounted within the sign case.

Each circuit shall be over-current protected. Each circuit breaker shall be UL or ETL, or an approved equal, switching duty type. The service personnel lighting and convenience receptacle outlets shall be provided with ground fault interrupters.

Power supplies shall operate from 120- or 240-volts-alternating-current power. The LED displays shall be operated at low internal DC voltage not exceeding 24 volts direct current. Power supplies shall be solid state electronic switching regulated output. The display shall be powered with two or more supplies wired in a redundant parallel configuration such that the supplies provide equal amounts of current to the display. When a power supply fails, the remaining supplies shall be capable of providing sufficient power to the sign display (20 milliampere to every LED on the line when the air around the power supply is at 60 degrees Celsius) and electronics.

Power supplies shall operate from -30 degrees Celsius to +60 degrees Celsius. Power supplies shall be short-circuit protected by DC power off and shall reset automatically after 5 seconds of AC power off. Power supplies shall also be protected by a minimum overload allowance of 105 percent and have an efficiency rating of at least 75 percent. The power supply shall be UL or ETL listed. Power supplies may be mounted either above or below the interior walkway of the housing. Units mounted above shall not encroach on the 2-foot-wide, 6-foot-high clear space above the walkway. Units placed beneath the walkway shall be mounted above the bottom surface of the housing with a chair bracket to provide protection against water damage.

All signs shall be unaffected by surges or transient voltages normally experienced on commercial and industrial power lines. Signs will be protected from surges and transient voltages by the incorporation of metal-oxide varistor (MOV) devices at the AC line circuit input utilization of a multi-section L-C filter ahead of the sign electronics power supply. Protection against abnormally low and high voltages will be provided by an electronic voltage detection circuit controlling the AC input power with a suitably selected contact relay.

An AC line monitor shall be provided to monitor the AC signal entering the sign. If three consecutive positive pulses are not detected, the AC line monitor will relay a signal to the DMS controller indicating power has failed. The DMS controller will then send a signal to the drivers to blank the sign or display the default message.

All signs shall be equipped with lightning protection, including electrical service and telephone service, as appropriate. Protection from lightning shall include gas discharge devices followed by zener diodes for data entry connections to the sign. Proper grounding of the sign housing shall be the responsibility of Design-Build Contractor

Mounting Hardware

Mounting hardware shall be supplied with the DMS. The mounting hardware shall include those devices shown on the Plans and all other appurtenant hardware, connectors, bolts, structural stiffening members, etc., necessary to attach the DMS to the structural supports.

Construction Requirements

Installation

Upon delivery to a storage location or to the site of installation, place the DMS in a manufacturer-approved manner, including supports that keep the sign off the ground and in a stable position. Supply all mounting bracket and required hardware for the permanent mounting of the DMS. Supply bolts if the lifting eyebolts are removed from the DMS after installation, to plug and seal the holes to prevent water from entering the DMS housing. If the lifting bolts are to be removed, provide compatible lifting bolts to Department for possible future use.

DMS Testing and Acceptance Requirements

Conduct such tests as necessary to ensure each DMS meets the requirements and specifications. INDOT or Department Representative reserves the right to witness and verify, or to appoint a representative to witness, all product testing during manufacture of the DMS. If the FAT is performed at a location more than 100 miles from the Site, the Design-Build Contractor

shall reimburse travel costs for up to four Engineer or Department Representatives.

Factory Acceptance Testing (FAT)

The FAT shall be performed at the DMS vendor's manufacturing facility. FAT is required prior to shipping of any DMS and shall include the following, at a minimum:

Passage of the NEMA 250 Water Spray Test with no visible signs of water leakage through any of the sign housing seams.

Proof of the 48 hours of continuous operation of the FAT DMS at each of two test conditions: 25 degrees Fahrenheit (first test) and 125 degrees Fahrenheit (second test).

Post-FAT, INDOT will audit and approve all burn-in test logs for each DMS prior to that DMS shipping from the factory.

The physical verification through inspection by INDOT or INDOT Representative that the DMS meets the special provision and the approved submittal and shop drawings.

Post-Delivery Testing and Operation

Prior to delivery of the DMS, the site shall have all lightning and surge suppression and grounding and bonding performed and accepted. Upon the delivery of each DMS to the location designated by INDOT [determine if locations will be supplied in the RID] and as shown on the Plans, provide permanent power for demonstration of the DMS' functions in accordance with the requirements and specifications and for proof that the DMS has not been damaged during shipment. Maintain the DMS power feed from the day of delivery to Final Acceptance, thereby protecting the interior electronics within the DMS from environmental degradation.

Post-Delivery Test Plan

Develop and submit to INDOT a DMS Post-Delivery Test Plan with the working drawings. The test plan shall demonstrate the complete functionality and integrity of the DMS after shipment and post-delivery. The plan will describe test procedures, detail the features being tested, and the detail the expected values that demonstrate DMS compliance.

Testing Schedule

All DMSs will be tested in accordance with the INDOT-approved Post-Delivery Test Plan. Schedule and conduct the post-delivery tests at a time approved by INDOT.

Reporting Requirements

Submit vendor and third-party reports verifying testing procedures, testing dates, and testing results to INDOT. The report will document the comparison of test results to the specifications detailed herein. The report will clearly identify any failure to conform to the specifications.

Failure to conform to testing procedures will be considered a defect of the equipment, and will thereby be subject to rejection by INDOT. Rejected equipment may be offered again for a retest. The retest shall fully comply with the test procedure, and the DMS is retested by the vendor or third party. Evidence of conformance of the test shall be submitted to INDOT.

Failure of any DMS to conform to the Design Documents, Construction Documents, or the PPA Documents will be considered a Defect, and the DMS is thereby subject to rejection by INDOT. Rejected equipment may be offered again for a retest, provided that all nonconformances have been corrected and retested by the vendor and evidence thereof has been submitted to INDOT.

Final FAT and product test reports showing complete compliance with specifications shall be submitted for review and comment by INDOT before Design-Build Contractor releases the DMS for shipment.

Conduct final inspection and acceptance of the DMS after:

1. Approval of the product testing report
2. Approval of the FAT report
3. Delivery of the DMS to a site designated by INDOT
4. Proof and verification of the DMS continuous operation post-delivery
5. Approval of the reports documenting the results of the post-delivery test

Warranty

The DMS device and all ancillary equipment shall be covered under full manufacture warranty for parts for two years after Final Acceptance. The mounting of a radio antenna and/or pole to the DMS shall not void this warranty. The manufacturer shall submit warranty information on company letterhead to INDOT with the authorizing company representative's signature. Warranty information will include shipping and replacement part procedures that allow INDOT to obtain a warranty replacement of defective parts in a timely manner. Standard warranties will be issued in INDOT's name.

Supply a DMS factory-trained technician to observe and oversee the DMS and ACP installation process for each sign. The technician is to verify that the installation practices follow the DMS vendor's standard operating procedure and that DMS vendor's warranty was not in any way voided or limited during the installation.

Once accepted by INDOT and upon Design-Build Contractor's request, the DMS warranty will begin.

Warrant that:

1. All Work furnished pursuant to the contract documents will conform to all professional engineering principles generally accepted as standards of the industry in the state.
2. The DMS will be free of defects.
3. Materials and equipment furnished under the PPA Documents will be of good quality and, when installed, will be new.
4. The Work will meet all of the requirements of the PPA Documents.

5. The Design Documents and Construction Documents for the DMS devices and ancillary equipment selected and prepared for use during Construction Work are appropriate for their intended use.

The Design-Build Contractor shall document all installation activities, including the quantity, brand, model/part numbers, and test results of all materials used. Provide an installer-signed list of the materials installed with the required documentation.

DMS Box Truss Structure

Overhead DMS shall be installed on DMS box trusses, per INDOT Standard Drawings.

Portable Changeable Message Signs

Portable Changeable Message Sign (PCMS) trailers shall be provided to facilitate traffic management in work zones during the construction and warn travelers to be prepared for construction activities and slowing traffic. The numbers and locations of PCMS trailers shall be determined by construction staging plans in accordance with INDOT Guidelines for PCMS, MOT, Haul Routes and Access.

The Design-Build Contractor shall coordinate with the Department to request the appropriate installation locations message(s) to display on the PCMS.

INTELLIGENT TRANSPORTATION SYSTEMS FIELD CABINETS

Design-Build Contractor shall furnish and install ITS controller cabinets per INDOT Standard Specifications and Standard Drawings. Design-Build Contractor shall design and install an appropriate foundation for the ITS controller cabinet in accordance with the applicable Department foundation design standard. Each cabinet foundation shall have a concrete footpad surrounding the foundation and shall be a minimum width of three feet. Materials

Design-Build Contractor shall be responsible for furnishing, insuring, transporting, and storing (for the interim) all materials associated with the ITS equipment cabinet, including power supply unit, equipment racks, circuit breakers, interface cables, and conduit entries.

Design Criteria

Each ITS equipment cabinet shall meet the required NEMA rating and shall be fabricated with approved material in accordance with pertinent Department standards.

Design-Build Contractor shall be responsible for the design and installation of work pads for maintenance and repairs, and guide railings or traffic barriers if within clear zones, as required by OSHA, INDOT TMC standards.

Concrete work pads shall be furnished and installed at each cabinet site to provide a level and dry maintenance platform for maintenance and repair activities. This Work shall also include excavation, gravel base, backfilling, and soil grading to support the concrete work pad at the cabinet site.

ITS equipment cabinets shall be designed for access by a single agency, unless joint access is explicitly agreed to by all involved stakeholders.

Construction Requirements

Design-Build Contractor shall be responsible for the design and installation of ITS equipment cabinets, concrete bases (for ground-mounted only), and concrete work pads.

The concrete work pads shall be level. Design-Build Contractor shall install conduit entries for fiber-optic communication drop cables from ITS backbone handholes and power conductors from power suppliers. All cables shall be labeled accurately to allow for future identification. Conduit stubs shall be provided and the number shall be configured for future power and communications usage in accordance with Department standards and requirements of the PPA Documents.

ITS COMMUNICATIONS SYSTEM

Materials

All fiber optics used in this Project shall be single-mode fiber. The general material elements are as follows:

Provide fiber-optic cables and fiber-optic cable splices as required to connect each ITS equipment cabinet and ITS elements to the existing backbone communication system in the final condition.

ITS field Ethernet switches shall support a minimum of 24 10/100 Ethernet ports. Provide two 10/100/1000/SFP-gigabit ports. Additionally, the switches shall support the following:

1. SFP support: SX, LX, XD, ZX, CWDM, 100FX, and T1
2. Resilient Stacking: up to 8 units/192 ports per stack
3. Stacking ports: 2 built-in HiStack ports per switch
4. Total stacking capacity: 320 gigabits per second
5. Individual switch packet throughput: 6.6 megapulses per second
6. Individual switch capacity: 48.8 gigabits per second
7. Concurrent VLANs: 256
8. Jumbo frame support on gigabit ports
9. Maximum MAC addresses: 8,000

All materials shall be furnished in accordance with the material requirements as stipulated under Department standards.

Design Criteria

Design-Build Contractor shall design drops off the existing fiber optic backbone to the ITS cabinets for connection to ITS elements. General design criteria elements are as follows:

Provide an Internet protocol (IP)-based system with a fully redundant architecture, allowing automatic failover of data flow to a secondary path or segment in the case of a primary equipment failure or fiber break. The ITS communication system backbone shall be rated for a 10-gigabit transfer rate, minimum. ITS field switches shall be rated for a 1-gigabit uplink transfer rate, minimum. Downlink ports at the field switches shall be 10/100BaseT.

Where required, Design-Build Contractor shall provide a field processor to act as terminal server, video encoder, and/or to perform data field processing.

The maximum number of elements assigned to a network path shall not exceed one-third of the path’s throughput capacity. Design-Build Contractor shall be responsible for providing any modifications to the existing communication networks required to integrate new devices.

The fiber optic network topology shall not include daisy chain as an option. All sites shall be home run to an existing core switch located at a communications hub.

Construction Requirements

All equipment and components shall be installed in accordance with the manufacturer's recommended procedures. All fiber-optic terminations shall be labeled with an approved naming convention.

Testing Requirements

Design-Build Contractor shall conduct installation testing as part of the design and construction process, and component/subsystem testing during construction, to ensure that the devices perform per the manufacturer's specifications. Vendor-unique software or hardware used to verify proper operation of a component or used to troubleshoot a component may be used by Design-Build Contractor. Design-Build Contractor shall provide this vendor-unique software or hardware to INDOT as part of the test equipment package.

Design-Build Contractor shall also furnish INDOT with any special or unique test equipment that is required to maintain and/or test the system after Final Acceptance. The test equipment shall be identified in the associated Design Review submittal.

At the option of INDOT, certain items of support equipment shall be tested by being installed in place of a similar item of equipment in a field or central location that has already passed acceptance testing. Testing shall be witnessed by INDOT.

Tests shall be scheduled to allow a representative from INDOT to witness the test. INDOT shall be notified a minimum of 72 hours prior to the commencement of each test. All test plans and the test procedures for the component and/or subsystem being tested shall be approved by INDOT before any testing is conducted. Additionally, Design-Build Contractor shall provide INDOT 72 hours notification of an anticipated disruption of any services. Concealed Work (including underground) shall be tested by Design-Build Contractor and witnessed by INDOT prior to covering.

Instruments used by Design-Build Contractor shall be regularly and accurately calibrated and maintained in good working condition. Test reports shall include copies of documentation (calibration reports or tags) demonstrating calibration within one year of the start of testing. Design-Build Contractor shall provide all test instruments.

ITS Vaults and Handholes

Description

Design-Build Contractor shall provide handholes and vaults to support the cable and conduit installation of this Project.

Provide a vault at each planned fiber-optic cable splice location. Also provide a vault at one end of each bored conduit section. Space ITS vaults at no more than 2,000-feet intervals. Handholes may be proposed at interim locations to facilitate cable installation or relocations, with locations to be determined based on construction staging requirements.

Provide a communications handhole within 6 feet of each ITS location to facilitate the installation of cabling to the cabinet.

Materials

All handholes and vaults shall be in conformance with the Project Standards.

Construction Requirements

Handhole and vault covers shall be horizontally stamped as "TRAFFIC MANAGEMENT SYSTEM" across the center of the lid.

All conduit between handholes shall be complete and continuous. All connections between sections of conduit shall be made to be watertight and shall be tested with compressed air prior to installing cables. Grouting fill surrounding conduit entries at the handholes shall be made watertight.

Handholes shall be precast with the top of the handhole sloped to match the final grade.

Fiber-Optic Cable

Description

Under these items, Design-Build Contractor shall furnish and install ribbon-style, single-mode, fiber-optic cable of the number of fibers determined using the design criteria above.

Materials

The single-mode, fiber-optic cable shall incorporate a ribbon-style design. The cable shall be qualified to the requirements of Rural Utility Service (RUS) 7 CFR 1755.900 (PE-90) for armored cable (as required by this specification), and shall be new, unused, and of current design and manufacture.

Experience Requirements

Design-Build Contractor shall meet the experience requirements under the subsequent subsection, Fiber-Optic Drop Cable.

Fiber-Optic Drop Cable

Description

The fiber-optic drop cable is used for installing fiber-optic cable into ITS control cabinets and relay shelters. This ITS drop cable is used for connectivity between a primary fiber trunk, or feeder cable, and various field devices such as CCTV cameras at field locations as shown on the Plans.

Materials

The fiber-optic ITS drop cable shall include a factory pre-terminated, factory pre-tested connector module with pigtails that splice into the primary fiber trunk. This connector module mounts into the ITS field cabinet enclosure or on a standard 19-inch rack rail. The fiber-optic ITS drop cable shall have the following specifications:

1. Single mode
2. Fiber count: 6 fiber
3. Connector #1: SC (factory pre-terminated)
4. Connector #2: Pigtail length of 150 feet

5. Mounting plate for cabinet rack

6. Insertion Loss: 0.2 decibel typical

7. Return Loss: > -40 decibel SPC

8. Tensile Strength: 50 pounds (220 Newtons) <0.20 decibel change

9. Temperature Cycling: 40 degrees Fahrenheit (-40 degrees Celsius) + 158 degrees Fahrenheit (70 degrees Celsius), 40 cycles < 0.20 decibel change

10. Ferrule material – Ceramic

11. Housing material – Acrylic, UL94V0

The cables shall use dispersion unshifted fibers. The fibers shall comply with International Telecommunications Union (ITU) G.652.D. The optical and physical characteristics of the uncabled fibers shall include the following:

1. Core Diameter: 8.3 µm (nominal)

2. Numerical Aperture: 0.14

3. Zero Dispersion Wavelength: 1300-1322 nm

4. Zero Dispersion Slope: 0.092 ps/(nm^2*km) (maximum)

5. Cladding Diameter: 125.0 ± 0.7µm

6. Core-Clad Concentricity: 0.05µm maximum

7. Cladding Non-Circularity: 1 percent maximum

8. Coating Diameter: 245 ± 10 µm

9. Coating-Cladding Concentricity: 12 µm maximum

10. Mode Field Diameter: 9.2µm±0.4µm at 1310nm

11. Mode Field Diameter: 10.4µm±0.5µm at 1550nm

12. Dispersion: 18.0 ps/(nm*km) maximum at 1550nm

The number of fibers in each cable shall be as determined in the design.

The maximum attenuation of any cabled fiber shall not exceed 0.4 decibels per kilometer at 1,310 nanometers and shall not exceed 0.3 decibels per kilometer at 1550 nanometers.

The cable shall be capable of withstanding a minimum-bending radius of 20 times its outer diameter during installation and 10 times its outer diameter during operation without changing the characteristics of the optical fibers.

The cable shall meet all of specified requirements under the following conditions:

1. Shipping/storage temperature: -58 degrees Fahrenheit to +158 degrees Fahrenheit (-50 degrees Celsius to +70 degrees Celsius)

2. Installation temperature: -22 degrees Fahrenheit to +158 degrees Fahrenheit (-30 degrees Celsius to +70 degrees Celsius)

3. Operating temperature: -40 degrees Fahrenheit to +158 degrees Fahrenheit (-40 degrees Celsius to +70 degrees Celsius)

4. Relative humidity from 0 percent to 95 percent, non-condensing

Armor

A steel armor, plastic coated on both sides, is required for direct buried cable installed under the provisions of this Technical Provision. An armor is optional for duct and aerial cable. The plastic- coated steel armor shall be applied longitudinally directly over the core wrap or the intermediate jacket and have a minimum overlap of 3.0 millimeters.

The uncoated steel tape shall be electrolytic chrome coated steel (ECCS) with a thickness of 0.155 ± 0.015 millimeters.

The reduction in thickness of the armoring material due to the corrugating or application process shall be kept to a minimum and shall not exceed 10 percent at any spot.

The armor of each length of cable shall be electrically continuous with no more than one joint or splice allowed per kilometer of cable. This requirement does not apply to a joint or splice made in the raw material by the raw material manufacturer.

The breaking strength of any section of an armor tape, containing a factory splice joint, shall not be less than 80 percent of the breaking strength of an adjacent section of the armor of equal length without a joint.

Construction Requirements

Coordinate layout and installation of fiber optic drop cable with other installations. Revise locations and elevations from those indicated as required to suit field conditions and as approved by INDOT at their sole discretion.

Experience Requirements

Personnel involved in the installation, splicing, and testing of the fiber-optic cables shall meet the following requirements:

Possess a minimum of three years’ experience in the installation of fiber-optic cables, including fusion splicing, terminating, and testing single-mode fibers.

Demonstration of the installation two systems where fiber-optic cables are outdoors in conduit and where the systems have been in continuous satisfactory operation for at least two years. Design-Build Contractor shall submit as proof photographs or other supporting documents and the names,

addresses, and telephone numbers of the operating personnel who can be contacted regarding the satisfactorily installed fiber-optic systems.

Design-Build Contractor shall arrange for INDOT to witness, at INDOT's discretion, one satisfactorily installed fiber-optic cable system (which may be one of the two in the preceding paragraph) for each installer to provide proof of competency.

Installers shall be familiar with the cable manufacturer's recommended procedures for installing the cable. This shall include knowledge of splicing procedures for the fusion splicer being used on this Project and knowledge of all hardware such as breakout (furcation) kits and splice closures. Design-Build Contractor shall include documented procedures in the Construction QA/QC Plan to be used by construction inspectors.

Personnel involved in testing shall have been trained, by the manufacturer of the fiber-optic cable test equipment to be used, in fiber-optic cable testing procedures. Proof of this training shall be submitted to INDOT as part of the Construction Quality Management Plan. In addition, Design-Build Contractor shall submit documentation of the testing procedures for approval by INDOT.

Cable Installation in Conduit

Design-Build Contractor shall provide a cable-pulling plan, identifying where the cable will enter the underground system and the direction of pull. This plan will address locations where the cable is pulled out of a handhole/vault, coiled in a figure eight, and pulled back into the handhole. The plan shall address the physical protection of the cable during installation and during periods of downtime. INDOT will have 7 days to provide comment and installation shall not commence until all comments are satisfactorily addressed. INDOT's review will be for the operation on the highway and does not include an endorsement of the proposed procedures. Design-Build Contractor shall be responsible for the technical adequacy of the proposed procedures.

During cable-pulling operations, Design-Build Contractor shall ensure that the minimum bending of the cable is maintained during the unreeling and pulling operations. Entry guide chutes shall be used to guide the cable into the handhole/vault conduit ports. Lubricating compound shall be used to minimize friction. Corner rollers (wheels), if used, shall not have radii less than the minimum installation-bending radius of the cable. A series array of smaller wheels can be used for accomplishing the bend if the cable manufacturers specifically approve the array.

The pulling tension shall be continuously measured and shall not be allowed to exceed the maximum tension specified by the manufacturer of the cable. Fuse links and breaks can be used to ensure that the cable tensile strength is not exceeded. The pulling system shall have an audible alarm that sounds whenever a preselected tension level is reached. Tension levels shall be recorded continuously and shall be given to INDOT upon request.

The cable shall be pulled into the conduit as a single component, absorbing the pulling force in all tension elements. The central strength member and Aramid yarn shall be attached directly to the pulling eye during cable pulling. "Basket grip" or "Chinese-finger type" attachments, which only attach to the cable's outer jacket, shall not be permitted. A breakaway

swivel, rated at 95 percent of the cable manufacturer's approved maximum tensile loading, shall be used on all pulls. When simultaneously pulling fiber-optic cable with other cables, separate grooved rollers shall be used for each cable.

Operation and Maintenance Documentation

After the fiber-optic cable plant has been installed, Design-Build Contractor shall submit to INDOT ten complete sets of operation and maintenance documentation. The documentation shall, as a minimum, include the following:

1. Complete and accurate as-built diagrams showing the entire fiber-optic cable plant, including the locations of all splices.

2. Final copies of all approved test procedures.

3. Complete performance data of the cable plant showing the losses at each splice location and each terminal connector.

4. Complete parts list, including names of vendors.

Testing Requirements

Design-Build Contractor shall include detailed test procedures in the Construction Quality Management Plan prior to any tests being conducted. All fibers shall be tested bi-directionally at both 1,310 nanometers and 1,550 nanometers with both an optical time-domain reflectometer (OTDR) and a power meter and optical source. For testing, intermediate breakout fibers may be concatenated and tested end to end. Design-Build Contractor shall resolve any discrepancies between the measured results and the requirements of this section to the satisfaction of INDOT.

Design-Build Contractor shall provide the date, time, and location of any tests required by this section to INDOT. Upon completion of the cable installation, splicing, and termination, Design-Build Contractor shall test all fibers for optical continuity loss, events above 0.1 decibels, and total attenuation of the cable. The test procedure shall be as follows:

A certified technician utilizing an OTDR and optical source/power meter shall conduct the installation test. The technician is directed to conduct the test using the standard operating procedures defined by the manufacturer of the test equipment. All fibers installed shall be tested in both directions.

The method of connectivity between the OTDR and the cable shall be a factory patch cord of a length equal to the "dead zone" of the OTDR. Optionally, the technician can use a factory "fiber box" of 328 feet minimum with no splices within the box.

At the completion of the test, Design-Build Contractor shall provide two copies of documentation of the test results to INDOT. The test documentation shall be submitted as both a bound copy and a USB flash drive and shall include the following:

1. Cable and Fiber Identification:

    a. Cable ID

b. Cable location – beginning and end point

c. Fiber ID, including tube and fiber color

2. Operator name

3. Date and time

4. Set-up parameters

5. Wavelength

6. Pulse width (OTDR)

7. Refractory index (OTDR)

8. Range (OTDR)

9. Scale (OTDR)

10. Set-up option chosen to pass OTDR "dead zone"

11. Test results:

    a. OTDR test

    b. Total fiber trace

    c. Splice loss/gain

    d. Events > 0.10 decibels

12. Physical length (cable marking)

13. Fiber length (OTDR)

14. Optical source/power meter

15. Total attenuation

16. Attenuation (dB/km)

File format for the OTDR Test Results: The file format for the OTDR test results shall be Bellcore/Telcordia-compliant according to GR-196-CORE Issue 2, OTDR Data Standard:

1. GR 196, Revision 1.0

2. GR 196, Revision 1.1

3. GR 196, Revision 2.0 (SR-4731)

These results shall be provided in tabular form. The following shall be the criteria for the approval of the cable:

1. The test results shall show that the decibel per kilometer loss does not exceed +3 percent of the factory test or 1 percent of the cable's published production loss. However, no event shall exceed 0.10 decibels. If any event is detected above 0.10 decibels, Design-Build Contractor shall replace or repair the fiber including that event point.

2. The total loss of the cable (decibel), less events, shall not exceed the manufacturer's production specifications as follows: 0.5 decibels per kilometer at 1,310 nanometers and 0.4 decibels per kilometer at 1,550 nanometers.

If the total loss exceeds these specifications, Design-Build Contractor shall replace or repair that cable run at Design-Build Contractor's expense, both labor and materials. Elevated attenuation due to exceeding the pulling tension during installation shall require the replacement of the cable run at Design-Build Contractor's expense, including labor and materials.

The Design-Build Contractor shall label the destination of each trunk cable onto the cable in each handhole, vault, or cable termination panel.

Splicing Requirements

Splice locations shall be permitted only with the written approval of the Department. For approved locations, mainline splices will concatenate the fibers from the two cable segments, that is, the colors of the buffer tubes and fibers shall be the same across the splice. For splices that breakout the individual fibers, the fiber assignments shall be included in the submittal to the Department.

Slack Storage of Fiber-Optic Cables

As part of these items, slack fiber shall be supplied as necessary to allow splicing the fiber-optic cables in a controlled environment, such as a splicing van or tent. The following slack shall be provided:

1. ITS Cabinet: 5 feet
2. ATMS Handhole: 20 feet
3. ATMS Vault: 100 feet
4. Shelter, Relay: 100 feet

After splicing has been completed, the slack fiber shall be stored underground in ATMS vaults.

Cable Tagging

Fiber-optic cable shall be tagged inside handholes with yellow tape containing the text "CAUTION - FIBER OPTIC CABLE." In addition, permanent tags, as approved by INDOT, shall be attached to all cable in a handhole or other break-out environment. These tags shall be stainless steel, nominally 0.75 inches by 1.72 inches, and permanently embossed. These tags shall be attached with stainless steel straps and shall identify the cable number, the number of fibers, and the specific fiber count. Tags and straps shall be American Labelmark, Ideal Industries, National Band and Tag, Panduit, Seton Name Plate, Standard Signs, W.H. Brady, or approved equal.

FIBER-OPTIC SPLICE

Description

Design-Build Contractor will splice optical fibers from different cable sheaths and protect them with a splice enclosure at the locations shown on the Plans. Fiber splicing consists of in-line fusion splices for all fibers described in the cable plan at the particular location.

Two basic types of splices are identified. In a drop cable splice, the buffer tubes in the mainline cable are dressed out, and those fibers identified on the Plans are accessed and spliced to drop cables. A mainline splice involves the splicing of all fibers in the cable sheath to a second, continuing cable.

Materials

Splice enclosures shall be designed for use under the most severe conditions, such as moisture, vibration, impact, cable stress, and flex temperature extremes, as demonstrated by successfully passing the factory test procedures and minimum specifications listed below:

Physical Requirements

The enclosures shall provide ingress for up to four cables in a butt configuration. The closure shall prevent the intrusion of water without the use of encapsulates. For combined mainline and drop cable splices, a single-splice enclosure shall be used.

The enclosure shall be capable of accommodating splice organizer trays that accept mechanical or fusion splices. The splice enclosure shall have provisions for storing fiber splices in an orderly manner, mountings for splice organizer assemblies, and space for excess or un-spliced fiber. Splice organizers shall be re-enterable. The splice case shall be UL rated.

Enclosure re-entry and subsequent reassembly shall not require specialized tools or equipment. Furthermore, these operations shall not require the use of additional parts.

The splice enclosure shall have provisions for controlling the bend radius of individual fibers to a minimum of 1.5 inches (38 millimeters).

For splices in armored cables, the splice closure shall provide a method of bonding the armor from all sheaths entering the closure. It shall also provide a means of grounding the armor and closure at the splice location.

Factory Testing

Compression Test

The closure shall not deform more than 10 percent in its largest cross-sectional dimension when subjected to a uniformly distributed load of 300 pound-force (1,335 Newtons) at temperatures of 0 and 100 degrees Fahrenheit (−18 and 38 degrees Celsius). The test shall be performed after stabilizing at the required temperature for a minimum of two hours. It shall consist of placing an assembled enclosure between two flat parallel surfaces, with the longest enclosure dimension parallel to the surfaces. The weight shall be placed on the upper surface for a minimum of 15 minutes. The measurement shall then be taken with weight in place.

Impact Test

The assembled enclosure shall be capable of withstanding an impact of 20.7 foot-pound force (28 N-M) at temperatures of 0 and 100 degrees Fahrenheit (–18 and 38 degrees Celsius). The test shall be performed after stabilizing the enclosure at the required temperature for a minimum of two hours. The test fixture shall consist of 20-pound (9 kilogram) cylindrical steel impacting head with a 2-inch (50-millimeter) spherical radius at the point where it contacts the enclosure. It shall be dropped from a height of 12 inches (305 millimeters). The enclosure shall not exhibit any cracks or fractures to the housing that would preclude it from passing the water immersion test. There shall be no permanent deformation to the original diameter or characteristic vertical dimension by more than 5 percent.

Cable Gripping and Sealing Testing

The cable gripping and sealing hardware shall not cause an increase in fiber attenuation in excess of 0.05 decibels per fiber at 1,550 nanometers when attached to the cables and the enclosure assembly. The test shall consist of measurements from six fibers, one from each buffer tube or channel, or randomly selected in the case of a single fiber bundle. The measurements shall be taken from the test fibers before and after assembly to determine the effects of the cable gripping and sealing hardware on the optical transmission of the fibers.

Vibration Test

The splice organizers shall securely hold the fiber splices and store the excess fiber. The fiber splice organizers and splice-retaining hardware shall be tested per EIA Standard FOTP-II, Test Condition 1. The individual fibers shall not show an increase in attenuation in excess of 0.1 decibels per fiber.

Water Immersion Test

The enclosure shall be capable of preventing a 10-foot (3-meter) water head from intruding into the splice compartment for a period of seven days. Testing of the splice enclosure is to be accomplished by the placing of the enclosure into a pressure vessel and filling the vessel with tap water to cover the enclosure. Apply continuous pressure to the vessel to maintain a hydrostatic head equivalent 10 feet (3 meters) on the closure and cable. This process shall be continued for 30 days. Remove the enclosure and open to check for the presence of water. Any intrusion of water in the compartment containing the splices constitutes a failure.

Certification

Design-Build Contractor shall ensure that either the manufacturer or an independent testing laboratory has performed all of the above tests, and that the appropriate documentation has been submitted to INDOT. Manufacturer certification is required for the model(s) of enclosure supplied. It is not necessary to subject each supplied closure to the actual tests described herein.

Construction Requirements

The enclosure shall be installed according to the manufacturer's recommended guidelines. For mainline splices, the cables shall be fusion spliced. Forty-five days prior to start of the fiber-optic cabling installation, Design-Build Contractor shall submit the proposed locations of

the mainline splice points for review and comment by INDOT. The minimum distance between mainline splice points shall be at least 1000 feet.

Design-Build Contractor shall prepare the cables and fibers in accordance with the enclosure and cable manufacturers' installation practices. A copy of these practices shall be provided to INDOT for review and comment 21 days prior to splicing operations.

Using a fusion splicer, Design-Build Contractor shall optimize the alignment of the fibers and fuse them together. Design-Build Contractor shall recoat the fused fibers and install mechanical protection over them.

Upon completing all splicing operations for a cable span, Design-Build Contractor shall measure the mean bi-directional loss at each splice using an OTDR. This loss shall not exceed 0.1 decibel.

Design-Build Contractor shall measure the end-to-end attenuation of each fiber, from connector to connector, using an optical power meter and source. This loss shall be measured from both directions and shall not exceed 0.5 decibel per installed kilometer of single-mode cable. Measurements shall be made at both 1,300 and 1,550 nanometers for single-mode cable.

The cable installation shall satisfy the requirements of both the NEC (NFPA-70-2008) and the National Electric Safety Code (IEEE C2-2007). The standards require that the armor be bonded and grounded any time that the armor is interrupted or exposed by opening the sheath. These documents also provide minimum separations from foreign utilities.

For splices in armored cables, Design-Build Contractor shall ground the splice closure using a #6 AWG conductor or equivalent.

As directed by the sole discretion of INDOT, Design-Build Contractor, at no additional cost to INDOT, shall replace any cable splice not satisfying the Project Standards, PPA Documents, including this Section 16.

Design-Build Contractor shall secure the splice enclosure to the side of the splice facility using cable support brackets. All cables shall be properly dressed and secured to rails or racks within the ATMS vault. No cables or enclosures will be permitted to lie on the floor of the splice facility. Cables that are spliced inside a building will be secured to the equipment racks or walls as appropriate and indicated on the Plans.

FIBER-OPTIC PATCH CABLES

Description

This section describes furnishing fiber-optic patch cables for making fiber- optic network device connections with SC and LC connectors as shown on the Plans. This includes patch panel connections, network card connections, and other equipment.

Materials

All conductors shall have the following specifications:

Multimode Patch Cord

Attenuation:

1. 850 nanometers: 3.0 decibels per kilometer
2. 1,310 nanometers: 1.0 decibels per kilometer
3. Bandwidth:
4. LED: 1500/500 megahertz per kilometer OFL at 850/1,310 nanometers
5. 2000/500 megahertz per kilometer RML at 850/1,310 nanometers
6. Diameters Core: 50 µm
7. Cladding: 125 µm
8. Buffer: 900 µm
9. Fiber Type: Laser-optimized multimode
10. Jacket: PVC
11. Operating Temperature: -40 to +185 degrees Fahrenheit (-40 to +85 degrees Celsius)

Single Mode Patch Cord

1. Bend radius: Meets ANSI/TIA/EIA-568B.3 standard
2. Cladding: 125 µm
3. Core: 9 µm
4. Crush resistance: 750 Newtons per centimeter
5. Ferrule: Ceramic
6. Housing: Composite
7. Insertion Loss: 0.2 decibels typical
8. Operating Temperature: - 4 to +158 degrees Fahrenheit (-20 to +70 degrees Celsius)
9. Return Loss: ≥55 typical

10. Tensile Strength: 240 Newtons (54 pounds per 24.5 kilograms)

11. Wavelength: 1,310 nanometers, 1,550 nanometers

12. Maximum attenuation: 0.4 decibels, typical 0.2 decibels

Construction Requirements

Coordinate the layout and installation of fiber patch cables with other installations. Revise locations and elevations from those indicated as required to suit field conditions and as approved by INDOT.

FIBER-OPTIC PATCH PANEL ASSEMBLY

Description

This section describes furnishing fiber-optic patch panels for making fiber- optic terminations at the cable demarcation point sites. The fiber patch panel assembly consists of the following:

1. One fiber closet connector housing
2. Eight fiber panels

Materials

The fiber patch panels shall have the following specifications:

1. Rack mountable for 19-inch rack 4U in size
2. Housing accepts up to 12 SC simplex or SC duplex connector panels
3. connector panels shall be single-mode in 12 fiber configuration
4. Meets requirements of ANSI/TIA/EIA-568A and 606
5. SC adapters have ceramic sleeves

Construction Requirements

Coordinate the layout and installation of fiber patch panels with other installations. Revise locations and elevations from those indicated as required to suit field conditions and as approved by INDOT. The splice shall be a fusion splice as specified in the Technical Provisions and shall not exceed 0.1 decibels. Design-Build Contractor shall measure the mean bi-directional loss at each splice using an OTDR and provide the results to INDOT.

FIBER GIGABIT INTERFACE CARD MODULES

Description

The Fiber Gigabit Interface Card (GBIC) module inserts into the ITS switches to allow for a fiber connection.

Materials

The Fiber GBIC module shall be compatible with the ITS field, field relay, and core switches.

The Fiber GBIC module shall provide performance as follows:

1. Operating temperature of 32 degrees to degrees 140 degrees Fahrenheit
2. Connector type of LC
3. Medium Time Between Failure (MTBF) of 807,000 hours
4. Distance Range:
5. Short up to 500 meters for 50 µm multimode fiber
6. Medium up to 10 kilometers for 9 µm single-mode fiber
7. Long up to 40 kilometers for 9 µm single-mode fiber
8. Extended up to 70 kilometers for 9 µm single-mode fiber
9. Optical Budget:
10. Short 7 decibels
11. Medium 10.5 decibels
12. Long 17 decibels
13. Extended 20 decibels
14. Transmit/Receive wavelength:
15. Short: 850 nanometers
16. Medium: 1,310 nanometers
17. Long: 1,470-1,610 nanometers
18. Extended: 1,550 nanometers

Construction Requirements

Fiber GBIC cards shall be installed at each site that is to be connected to fiber.

INTELLIGENT TRANSPORTATION SYSTEM FIELD ETHERNET SWITCH, MANAGED

Description

The ITS field Ethernet managed switch is used to connect communications equipment and the AFP at camera sites, as well as provide relay communications to the ATMS network.

Materials

Provide materials conforming to the following specifications: Avaya 4526-T

Construction Requirements

Design-Build Contractor shall install the ITS field relay Ethernet switch in accordance with the manufacturer's instructions. Installation shall include all cables, mounting hardware, power supplies and associated equipment required to mount and interface the spur low-speed communications subsystem. Document all installation activities, including the quantity, brand, model/part numbers, test results of all materials used. Provide an installer-signed list of the materials installed with the required documentation.

INTELLIGENT TRANSPORTATION SYSTEM CORE ETHERNET SWITCH, MANAGED

Description

The ITS core Ethernet switch is used to connect the fiber backbone of the ITS field equipment to the rest of the communications network. This switch will be located in a conditioned shelter or building. The ITS core switch consists of the following:

1. One chassis with at least six slots
2. Two 100-240 VAC 1140W/1462W power supplies with appropriate power cord
3. Two switch fabric modules with 256 Gbps switch fabric capacity, 1.3 GHz CPU, 1 GB memory and compact flash slot
4. Two Ethernet interface modules with eight ports of autosensing 10Base-T/100Base-TX/1000Base-T, 24 ports for SFP style GBIC card and two 10Gigabit XFP style GBIC cards. Module shall be vendors' most current model with exact port counts listed above. Two 48-port autosensing 10Base-T/100Base-TX/1000Base-T Ethernet interface modules
5. One software kit, including base software necessary for operation of the switch. Design-Build Contractor shall obtain the latest version available from the manufacturer

Functional requirements:

1. Meet 99.999-percent error free operation; multiple protocol data communication over fiber optic and copper transmission mediums.
2. Perform to stated specifications over a temperature range of 32 degrees to 104degrees Fahrenheit and a humidity of 85 percent relative noncondensing.
3. Shall operate on 120 volt (plus or minus 10 percent) 60 Hz commercial power.
4. Standard EIA 19-inch rack mountable.

Materials

Provide materials conforming to the following specifications:

1. Switch architecture: 720Gbps gross throughput
2. Switch Fabric performance: up to 512Gbps in an Active/Active configuration
3. Frame forwarding rate: up to 380Mpps
4. Frame length: 64 to 1518 Bytes (802.1Q Untagged), 64 to 1522 bytes (802.1Q Tagged)
5. Jumbo Frame support: up to 9,000 Bytes (802.1Q Tagged)
6. Multi-Link Trunks: up to 128 Groups, with 8 Links per Group

7. VLANs: up to 4,000 Port/ Protocol/802.1Q-based
8. Multiple Spanning Tree Groups: up to 32
9. MAC Address: up to 64k
10. IP Interfaces: 1,972
11. Dynamic ARP Entries: up to 32k
12. VRRP Interfaces: up to 255
13. IP Forwarding Table: 250k
14. ECMP Routes: up to 5k
15. RIP Instances: up to 64
16. RIP Interfaces: up to 200
17. RIP Routes: up to 10k
18. OSPF Instances: up to 64
19. OSPF Adjacencies: up to 80
20. OSPF Routes: up to 50k
21. BGP Peers: up to 250
22. BGP Routes: up to 250k
23. SPB C-VLANs: up to 1,500
24. SPB IS-IS Adjacencies: up to 50
25. SPB IP Routes for L3 VSN: up to 25k
26. SPB IP Routes for IP VPN-Lite/SPB: up to 250k
27. VRF-Lite Instances: up to 255
28. MPLS LDP LSPs: up to 16k
29. MPLS Tunnels: up to 2,500
30. PIM Active Interfaces: up to 200
31. PIM Neighbors: 80/up to 200 for all VRFs
32. IP Multicast Streams: up to 4k

Construction Requirements

The ITS core switch shall be installed in accordance with the manufacturer's instructions and per the Plans. All materials shall be installed in a neat and professional manner, subject to INDOT's approval. All installation services will comply with all warranty provisions and warranty contract maintenance services in accordance with these specifications.

Installation shall include all cables, mounting hardware, power supplies and associated equipment.

Document all installation activities, including the quantity, brand, model/part numbers, test results of all materials used. Provide installer signed list of the materials installed with the required documentation.

Integrate and test the switch and connections to communications equipment at the TMC's in Gary and Indianapolis.

PADLOCKS

Description

This Work shall consist of furnishing and installing padlocks for all cabinets, fence gates, box truss ladder gates, and enclosures specified in these Technical Provisions.

Materials

The padlock shall be classified as a high-security padlock with hardened shackle, laminated body, and 4-pin cylinder (minimum), and shall come complete with a weather cover to protect the lock body and cylinder from sand, dirt, water and ice. A wafer cylinder shall not be used. Keys shall be provided to INDOT with each padlock supplied. All padlocks shall be keyed alike and identical to the keys currently in use by INDOT. The main body width of the padlock shall not exceed 3 inches and shall have a shackle length of 2.25 inches to 3.75 inches and a shackle diameter of 0.3125 inches.

Construction Requirements

For padlock information, contact the ITS Field Engineer, Indiana Department of Transportation, at 8620 East 21st Street, Indianapolis, Indiana 46219, (317) 899-8606. The contact person for the Gary TMC is Marc Antich, (219) 938-2016.

INTELLIGENT TRANSPORTATION SYSTEM ELECTRICAL POWER

Power Service Drop

Description

Work under this item shall include furnishing and installing all equipment necessary to provide a complete service point power entry. Electrical service, where required, shall be provided by the appropriate Utility Owner. A 100 Amp, 240/120 volts alternating current, 1-phase, 3-wire service shall be provided at power service drop locations. The service point locations shall be coordinated with the appropriate Utility Company. Work under this item includes overhead and underground service power drops for 120/240 volt. Design-Build Contractor shall pay for all costs required by the utility for service installation.

After coordination with the power company's representative, Design-Build Contractor shall submit a connection request form to INDOT. The Department shall forward this form to the power company, and INDOT will be responsible for paying bills after service is connected. The service drops shall be in accordance with these provisions and with 807.15.

Materials

The service drops shall be sized and equipped to support the electrical loads of the equipment. Meter sockets shall be installed in accordance with the requirements of the utility. Grounding shall be in accordance with 807.12 and shall be part of the service installation.

The outdoor rated disconnect switch shall be a NEMA 3R enclosure with multi-position (4 or 6) circuit breaker panel with 100 amp main circuit breaker, 3 pole, 600 volts. The enclosure shall be lockable with a padlock. Padlocks are to be in accordance with the padlock provisions.

In the event that the service point and cabinet are separated by mainline roadway lanes, collector/distributor lanes, ramp lanes or a distance greater than 500 feet (as measured along the electrical wire from the service point to the cabinet), an additional 3R rated electrical disconnect shall be installed within 25 feet of the ITS controller cabinet/DMS as a safety disconnect device.

Construction Requirements

All electrical Work associated with the service power drop installations shall be in accordance with the Design Documents, Construction Documents, Project Standards, and the manufacturer's written instructions.

As identified in the Plans or per INDOT request, where the proposed service point is more than 500 feet from the ATMS remote site, a second disconnect shall be provided at the ATMS site.

Wires and Cables

Description

This section shall consist of furnishing and installing wires and cables, and making all connections. The following sections of the Standard Specifications relate specifically to this section: 807; n 805; 920.01(c.

Deliver wire and cable according to NEMA WC-26.

Materials

Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include the following:

1. American Insulated Wire Corp., Leviton Manufacturing Co.
2. Brand-Rex Cable Systems, Brintec Corp.
3. Carol Cable Company, Inc.
4. Senator Wire & Cable Co.
5. Southwire Co.

Connector vendors for wires and cables:

1. Teledyne Penn-Union
2. ILSCO
3. Thomas & Betts Corp.
4. Electrical Products Division, 3M Co.
5. O-Z/Gedney Unit, General Signal

All conductors shall have insulation rated at 600 volts alternating current, with conductor temperatures not to exceed 194 degrees Fahrenheit (90 degrees Celsius) in dry locations and 167 degrees Fahrenheit (75 degrees Celsius) in wet locations.

Service Entrance: Type XHHW, copper conductor, in raceway

Branch Circuits: Type XHHW, copper conductor, in conduit at ATMS equipment cabinets/enclosures.

Connectors and Splices: UL-listed factory fabricated wiring connectors of size, ampacity rating, material, and type and class for application and for service indicated. Select to comply with this Project’s installation requirements.

Construction Requirements

Coordinate layout and installation of cable with other installations. Revise locations and elevations from those indicated as required to suit field conditions and as approved by INDOT.

All components and installation shall comply with NFPA 70, NEC. Provide products specified in this section that are listed and labeled as defined in the NEC, Article 100.

The Design-Build Contractor shall install wires and cables as indicated, according to the manufacturer's written instructions and the National Electrical Contractors Association Standard of Installation.

The Design-Build Contractor shall pull conductors into raceway simultaneously where more than one is being installed in same raceway.

The Design-Build Contractor shall use pulling compound or lubricant where necessary; compound used shall not deteriorate conductor or insulation.

The Design-Build Contractor shall use pulling means; including fish tape, cable, rope, and basket weave wire/cable grips that will not damage cables or raceway.

The Design-Build Contractor shall minimize conductor splices where possible.

All splices and connections shall comply with 807.

The Design-Build Contractor shall install splices and covers that possess equivalent or better mechanical strength and insulation ratings than conductors being spliced.

The Design-Build Contractor shall use splice and tap connectors that are compatible with conductor material.

The Design-Build Contractor shall examine conduits to receive wires and cables for compliance with installation tolerances and other conditions. Do not proceed with installation until unsatisfactory conditions have been corrected.

Testing

Upon installation of wires and cables and before electrical circuitry has been energized, the Design-Build Contractor shall demonstrate product capability and compliance with requirements.

Procedures

The Design-Build Contractor shall perform each visual and mechanical inspection and electrical test stated in InterNational Electrical Testing Association Standard ATS, Section 7. Certify compliance with test parameters.

The Design-Build Contractor shall correct malfunctioning products at site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

Power Vaults and Handholes

Materials

All handholes and vaults shall be in conformance with the Project Standards for construction.

Design Criteria

Design-Build Contractor shall provide handholes and vaults to support the cable and conduit installation of this Project.

The Design-Build Contractor shall provide a power handhole within 6 feet of each ITS location to facilitate the installation of cabling to the cabinet.

Construction Requirements

Handhole and vault covers shall be stamped as “TRAFFIC MANAGEMENT POWER” horizontally, across the center of the lid.

All conduits between handholes and/or vaults shall be complete and continuous. All connections between sections of conduit shall be made to be watertight and shall be tested with compressed air prior to installing cables. Grouting fill surrounding conduit entries at the handholes shall be made watertight.

Handholes shall be precast with the top of the handhole sloped to match the final grade. Vaults shall be installed such that the top is level and grading surrounding the vault shall be made level. Design-Build Contractor shall provide retaining walls as necessary to support the grading requirement.

INTELLIGENT TRANSPORTATION SYSTEM CONDUIT

Materials

Conduit materials shall be in accordance with the Project Standards.

Design Criteria

Design-Build Contractor shall provide a minimum of one 2-inch HDPE Schedule 80 conduit for electrical power and three 1.25-inch conduits of different colors (blue, orange, and green) for fiber communications. Provide additional conduit and larger conduit where required to meet the needs of this Project. Conduit installed for this Project shall support 100 percent expansion of the ITS. To support system expansion, maximum conduit fill for all new conduits shall not exceed 0.5 of the fill percentage recommended by Table 1, Chapter 9, of the NEC.

Wherever possible, conduit shall be installed in common trenches.

Bored conduit shall be installed perpendicular to roadway or other paved crossings.

All conduits shall be locatable, either by installing a tonable pull tape, armored fiber optic cable, or copper wire within the conduit wall.

Construction Requirements

Design-Build Contractor shall be responsible to repair any pavement or concrete that is damaged by boring operations. Design-Build Contractor shall install trenched, bored, or structurally mounted conduit in accordance with the Project Standards.

During trench backfilling, for exterior underground power, signal, and communications lines, Design-Build Contractor shall install continuous underground plastic line marker, located directly above line at 6 inches to 8 inches below finished grade. Where multiple lines are installed in a common trench or concrete envelope, do not exceed an overall width of 16 inches; install a single line marker.